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## Constructing a Reference Event List for NORESS

*Florence Rivière-Barbier*

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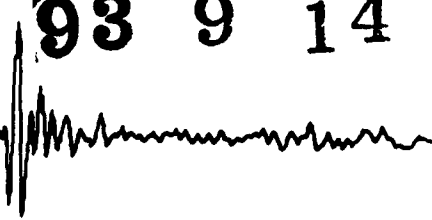
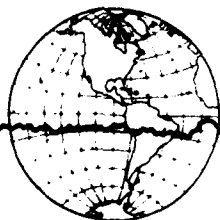
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Center for Seismic Studies  
1300 N. 17th Street, Suite 1450  
Arlington, Virginia 22209-3871  
Telephone: (703) 276-7900

Special Technical Report C93-06

August 25, 1993

## Constructing a Reference Event List for NORESS

*Florence Rivière-Barbier*



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## REPORT DOCUMENTATION PAGE

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## 1. INTRODUCTION

This report is summarizing part of a study using recordings of events from Scandinavia in order to construct a list of reference events for each of the Scandinavian arrays. The previous report (Rivière-Barbier, 1993) gives a thorough description of the procedure followed to define these reference events.

The results presented in this report were obtained using data recorded at the NORESS array. Figure 1 shows a map of Scandinavia on which were superimposed the different areas that were studied independently. Seventeen areas were studied using NORESS data: areas 26, 27, 31, 32, 33, 34, 46, 47, 48, 49, 50, 51, 52, 53, 62, 63 and 64.

Recordings on the vertical channel (sz) of the central element (NRA0) were used in the waveform comparison process. General information and the results of the processing are presented for each area in Appendix 1. Processing parameters are listed in Appendix 2. Lists of the mine locations from several sources, already provided in the previous report, are given in Appendix 3.

## 2. AREA DESCRIPTION

The area description follows the same pattern than in the previous report. The parameters used to characterize the areas are given below.

### *2.1. Latitude*

Upper and lower latitude limits of the studied area are given in this field. For the part of Scandinavia described in this report, the lowest latitude is 56 degrees and the highest latitude is 66 degrees. Area sizes in latitude are 2 degrees. All latitudes given in this report are North of the Equator.

### *2.2. Longitude*

Upper and lower longitude limits of the studied area are given in this field. For the part of Scandinavia described in this report, the smallest longitude is 4 degrees and the largest longitude is 24 degrees. Area sizes in longitude can vary from 1.5 degree to 6 degrees. Longitudes given in this report are East of the Greenwich meridian.

### *2.3. Number of events in IMS2*

This is the number of events located within a particular area by the IMS and stored in the IMS2 database account at the time of the selection, January 31, 1993.

At that time, the database contained events that occurred between November 1990 and January 27, 1993.

### *2.4. Local magnitude range*

The local magnitude range is used to select the events from a particular area. The range is used to obtain a representative data set of the area. The events were selected based

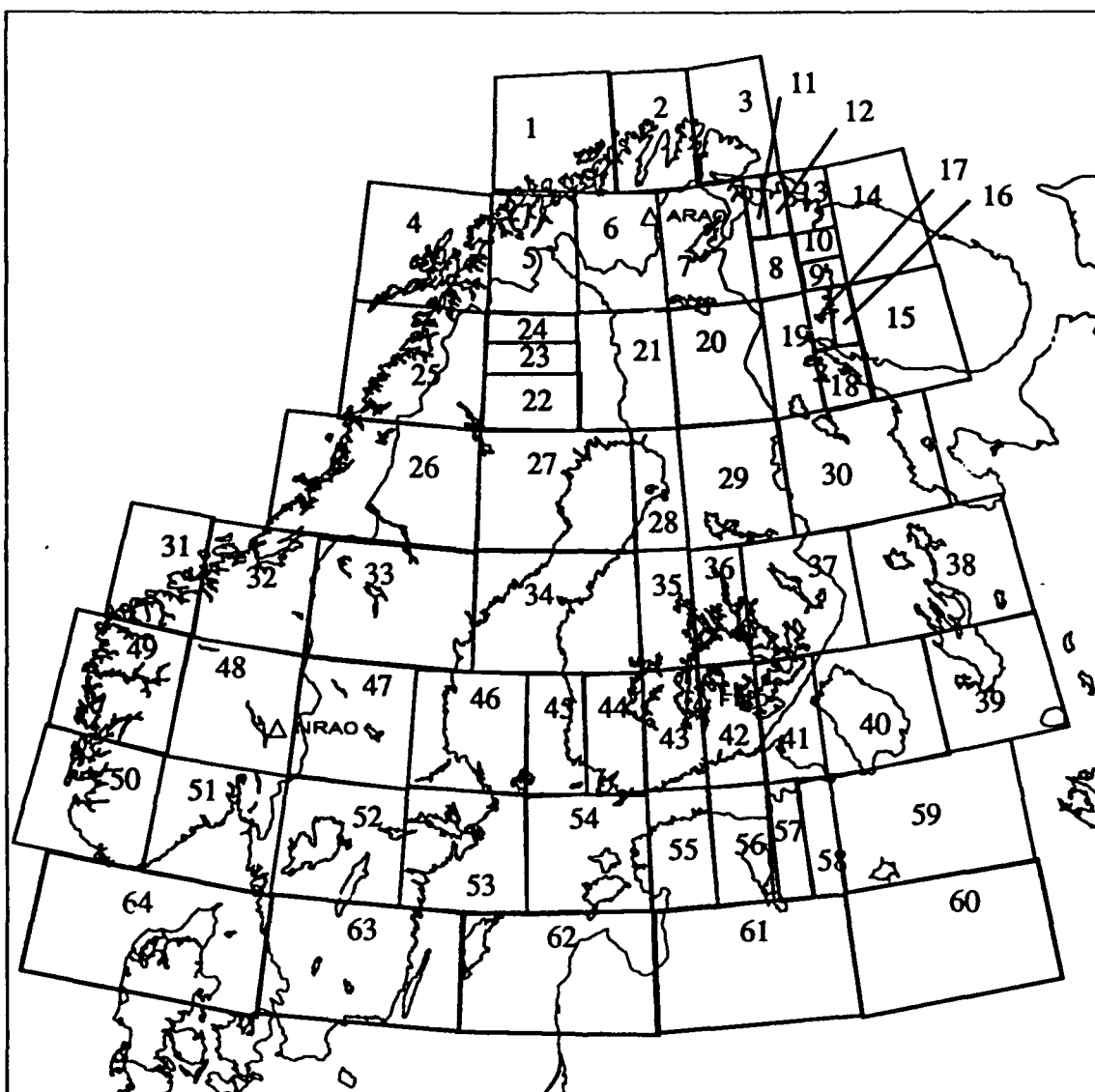


Figure 1: Map of Scandinavia showing the 64 areas that are being used to define a list of reference events for each array NORESS, ARCESS and FINESA. The arrays are represented by their central element: NRA0, ARA0, FIA0.

on decreasing magnitude in order to get the largest events. When no magnitude range is given, all events located in the area were used in the processing. This happened when too few large events were available for a given area.

### 2.5. Number of events within the magnitude range

This number is either equal to or lower than the number of events in the IMS data-

base. Not all events located by the IMS and whose locations are stored in the database have waveforms. Technical problems at the array, software and hardware failures, and misidentification by the expert system can lead to lost of waveforms.

#### **2.6. Number of processed events**

The number of processed events is, in most cases, smaller than the *number of events within the magnitude range*. A specific length of signal is required for the computation, and the waveform segment available on disk may not be long enough. Also, an event recording can be made of two waveform segments, a case that is not handled by the processing program.

#### **2.7. Frequency range used to process the data**

For each area, a frequency range is defined to filter the data. The high frequency corner is always set to 16.0 Hz. The low frequency corner varies from 2.0 to 3.5 Hz.

#### **2.8. Processed signal length**

The signal length needed for processing should include all phases and therefore, is distance dependent. The signal length is defined to contain the beginning of the first phase and the end of the last phase associated with the event. The total length includes the signal plus 1/8 of the signal length at each end since a 10% cosine taper is applied to the data.

#### **2.9. Number of reference events**

This gives the number of events that need to be used to identify most of the events located within a given area. The table listing these reference events gives the following information:

- the event number: related to the processing;
- the IMS orid: IMS event number in the database;
- the IMS arid: IMS number for the first phase associated with the event at the array;
- the IMS wfid: IMS waveform number, in this study only waveforms recorded at the central element of the array (NRA0) on the vertical channel (sz) were used;
- the threshold: lowest cross-correlation value between a given reference event characterizing a group and any event in this particular group. Below this value, events do not belong to the group represented by the reference event. When a reference event is defined for a group of only two events, no threshold value is given.
- the group: corresponds to the event classification using the cluster analysis method.

#### **2.10. Reported mine locations**

Scandinavia has a very large and important mining industry. The vast majority of the events recorded in the area are related to the mining activity either directly as mine blasts or indirectly like as induced events (tremors). In Appendix 3, lists of

the different mine locations are given. These lists have four main sources: SPOT photos, the bulletin published by the University of Helsinki, the Norwegian bulletin, and Joint Operations Graphic (JOG) maps from the American Defense Mapping Agency. The mine locations found on SPOT photos are the most reliable locations but the SPOT photos available cover only a small part of the studied area. The locations provided in the Helsinki bulletin have recently been updated based on SPOT locations and on information that the Finnish researchers have obtained directly from the mines. Based on these new locations, the Helsinki mine labelling changed after May 1991. This list is probably the most complete list for Scandinavia despite the fact that some large mines located outside of Finnish territory are missing. An attempt was made to map the old Helsinki mine labels with the new labels. This mapping is shown in the table giving the new Helsinki mine locations. The Norwegian bulletin gives a list of accurate mine locations located mostly in Norway. The JOG maps give accurate mine locations but they are not recent enough: some new mines may be missing and old mines may not be active any more. For each area, a table gives:

- the label: symbol used on the IMS maps,
- the location: latitude and longitude,
- the source of information.

## ***2.11. Number of events found in the Helsinki bulletin***

The bulletin published by the University of Helsinki provided extensive lists of events occurring in Scandinavia. Most of the mining events reported in this bulletin have a "manual location" which means that the Finnish analysts visually assigned these events to a particular mine. However, for this particular area, only events with an automatic location have been reported.

A software was used to match the events reported in the Helsinki bulletin with the studied events applying the following parameters:

- the distance between associated events should not be more than 1°,
- the difference in origin time should not be more than 20 seconds.

Forty-three events from the Helsinki bulletin were associated with an event from the IMS database. Five of them were identified as being "earthquakes" and five others as being "probably earthquakes".

For each area, a table listing the studied events that were found in the Helsinki bulletin based on the criteria described above gives:

- the event number: this number is related to the processing,
- the event orid: number identifying the event in the IMS database,
- the origin time: from the IMS origin table,

- the local magnitude: from the IMS origin table,
- the Helsinki location: either a latitude and longitude if the event was located automatically or a mine label if the event was located manually,
- the Helsinki identification: if the event was located manually, the label 'EXP' (for explosion) is used; if the event was identified as being a probable quarry blast, the label 'P. QB' is used; if the event was identified as being an earthquake, the label 'EARTH' is used; if the event was identified as being probably an earthquake, the label 'P.E.' is used. When the event was not identified in the Helsinki bulletin, no label is shown.
- the group: corresponds to the event classification using the cluster analysis method.

#### ***2.12. Events with the most reliable classification***

For each area, events were sorted into groups based on their waveform similarities. A table gives the list of the events included in each group. Events with a too low signal-to-noise ratio and events that were mixed with other events on the same waveform (except when these events were very large and when they all belonged to the same group) were not included in this list. The table includes the following information:

- the event number: this number is related to the processing,
- the event orid: number identifying the event in the IMS database,
- the origin time: from the IMS origin table,
- the location: from the IMS origin table,
- the local magnitude: from the IMS origin table,
- the group: corresponds to the event classification using the cluster analysis method.

#### ***2.13. Remarks***

For each area, comments are made about the events and their classification. Comparisons are made between mine locations and event locations. Any particular features seen on the data are reported.

#### ***2.14. Mine and event locations***

A map showing the IMS event locations and the mine locations from the Norwegian bulletin, the Helsinki bulletin and the JOG maps are plotted for each area. This map allows the comparison between the different sets of mine locations mentioned above as well as the comparison between the event locations and the mine locations.

### **3. CONCLUSION**

One-thousand-one-hundred-sixteen events were processed during this study. One hundred-eight reference events have been defined to represent the event types recorded at

NORESS for distances between 0 and 8 degrees. Among the studied event, five-hundred-seventy-seven events were reliably associated with a reference event and forty-three events were found in the Helsinki bulletin. Five of these events were identified as being "earthquakes" and five others as being "probably earthquakes". None of the remaining thirty-three events was identified as originating from a mine since they all had automatic locations.

About half of the events could not be sorted because either they had too low signal-to-noise ratios or they were unique. Proportionally to the total number of studied events, more reference events were needed to characterize events recorded at the NORESS array than at the ARCESS array. This confirms the large number of different signals recorded at the NORESS array.

As already noticed for the events located around the ARCESS array, several areas show clusters of events where no mine locations have been reported.

#### 4. REFERENCES

- Rivière-Barbier, F. 1993. Constructing a Reference Event List for ARCESS. *Center for Seismic Studies Annual Technical Report C93-03*. March 1992-March 1993.
- Ryall, F. 1993. Analysis summary of IMS Reprocessed Data. Internal Report. *Center for Seismic Studies*.

## APPENDIX 1



## AREA 26

*Latitude: 64 - 66°N*

*Longitude: 10 - 18°E*

*Local magnitude range: -*

*Number of events in IMS2: 27*

*Number of events within the magnitude range: 27*

*Number of processed events: 8*

*Frequency range used to process the data: 3 - 16 Hz*

*Processed signal length: 14s. before P, 134s. after P*

*Number of reference events: None*

*Reported mine locations:*

**Table 1: Mine locations for area 26**

Label	Latitude	Longitude	Origin
N9	64.07	11.20	Norw
N7	64.87	13.88	Norw
N8	65.93	13.88	Norw

*Number of events found in the Helsinki bulletin: None*

*Remarks:*

- This area shows very little seismic activity.
- Most of these events are unique and the others have too low signal-to-noise ratios to be sorted.

Mine and event locations:

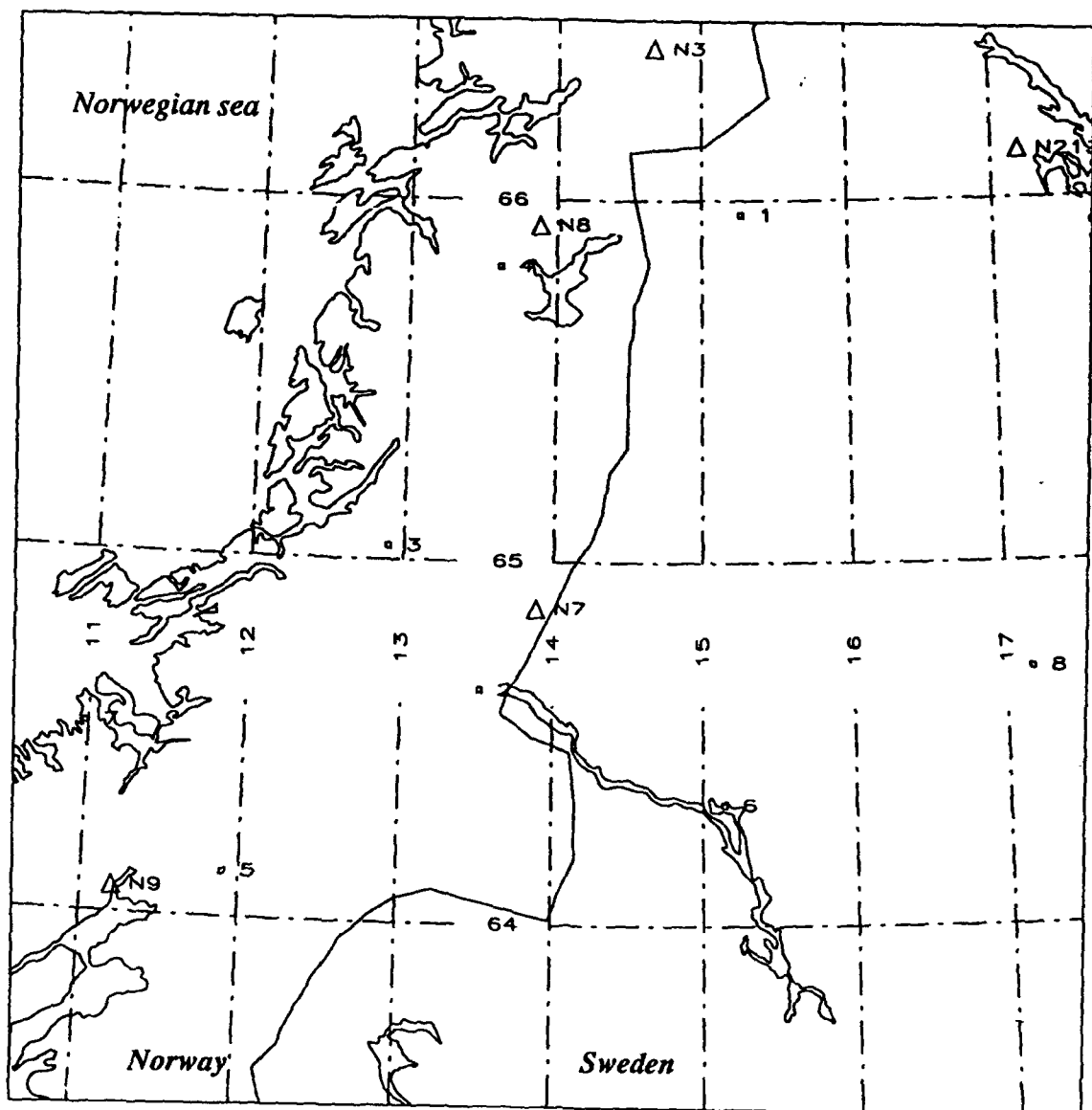


Figure 2: Mine and IMS event locations for area 26.

## AREA 27

*Latitude:* 64 - 66°N

*Longitude:* 18 - 24°E

*Local magnitude range:* -

*Number of events in IMS2:* 54

*Number of events within the magnitude range:* 54

*Number of processed events:* 15

*Frequency range used to process the data:* 3 - 16 Hz

*Processed signal length:* 14s. before P, 139s. after P

*Number of reference events:* None

*Reported mine locations:*

**Table 2: Mine locations for area 27**

Label	Latitude	Longitude	Origin
N220	64.05000	20.71670	Norw
N216	64.10000	19.58330	Norw
N214	64.13329	18.56670	Norw

*Number of events found in the Helsinki bulletin:* 6

**Table 3: Events found in the Helsinki bulletin for area 27**

Event #	IMS orid	IMS origin time		IMS ml	HEL location		HEL label	Group
1	11179	1/19/91	21:01:13.8	2.28	65.66	18.06	P.E.	?
10	327190	4/16/92	10:21:42.6	2.34	64.18	20.64	EART	?
12	338193	9/4/92	21:58:07.5	1.46	65.89	22.00	P.E.	?
13	340554	9/28/92	14:48:53.5	1.42	65.01	21.34	P.E.	?
3	41532	9/23/91	19:20:28.3	3.15	64.58	21.40	EART	?
4	301196	11/8/91	22:07:51.4	1.98	65.23	22.71	P.E.	?

**Remarks:**

- Most of these events show low signal-to-noise ratios or are unique events.
- The cluster seen on the map (Figure 3) consisting of events 6, 7, 8 and 9 corresponds to a group in the cluster analysis; but, their too low signal-to-noise ratios did not allow to verify this classification.

Mine and event locations:

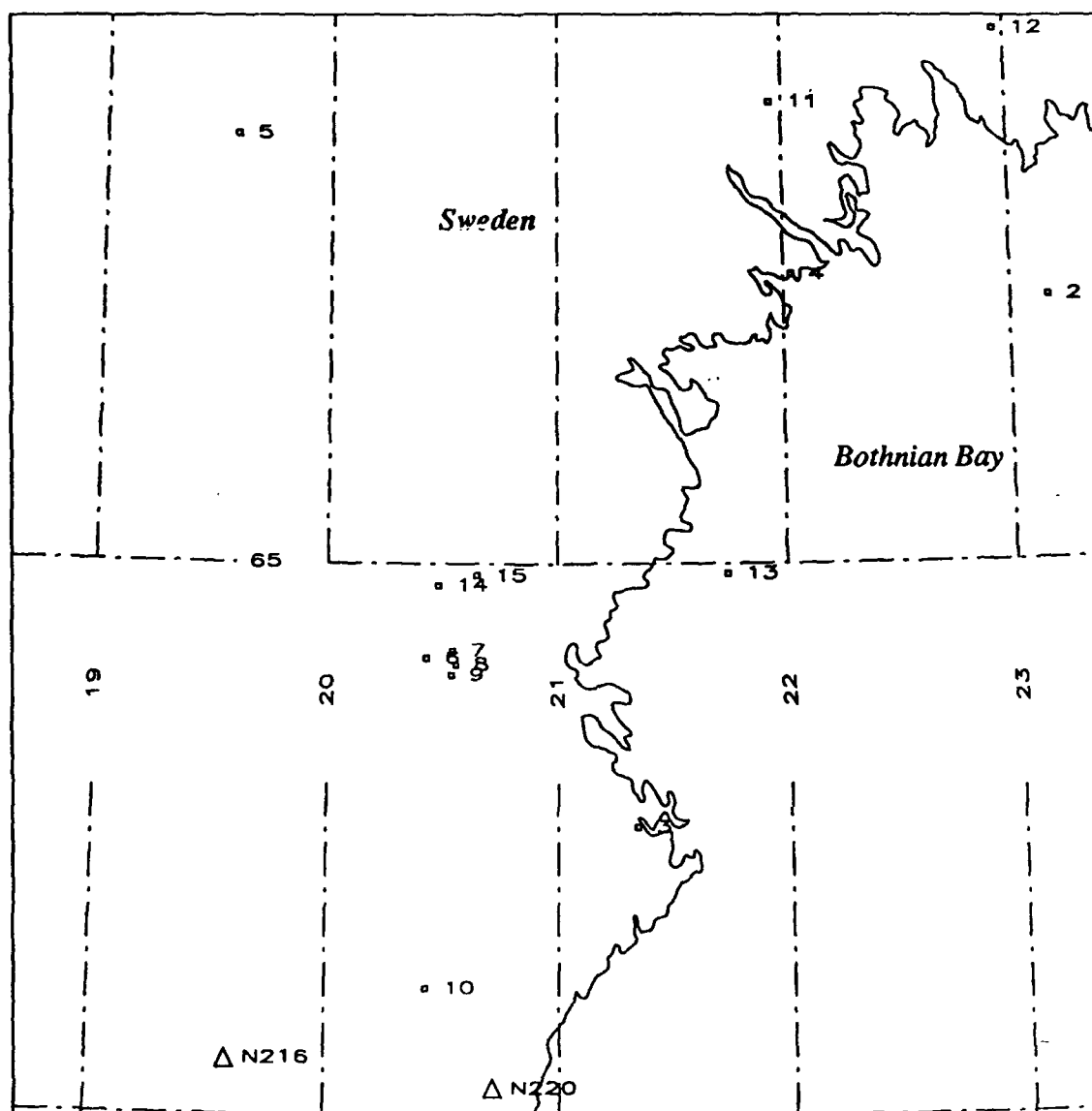


Figure 3: Mine and IMS event locations for area 27.

## AREA 31

*Latitude: 62 - 64°N*

*Longitude: 5 - 8°E*

*Local magnitude range: > 1.0*

*Number of events in IMS2: 147*

*Number of events within the magnitude range: 87*

*Number of processed events: 71*

*Number of events found in the Helsinki bulletin: None*

*Frequency range used to process the data: 2 - 16 Hz*

*Processed signal length: 7s. before P, 62s. after P*

*Number of reference events: 4*

**Table 4: Reference events for area 31**

Event #	IMS orid	IMS arid	IMS wfid	Threshold	Group
41	324452	1232237	1936695	0.80	A
68	342817	1501769	2807742	0.85	B
23	35150	883500	1123004	0.84	C
10	10235	613896	1375345	0.90	D

*Reported mine locations:*

**Table 5: Mine locations for area 31**

Label	Latitude	Longitude	Origin
N1	62.04000	5.52333	Norw

*Events with the most reliable classification:*

**Table 6: Sorted events for area 31**

Event #	IMS orid	Origin time		IMS lat.	IMS lon.	IMS ml	Group
2	2510	11/23/90	13:12:44.1	62.2775	7.5712	1.32	A
3	10221	11/24/90	14:56:10.3	62.4044	7.2551	1.35	A
4	2599	11/26/90	07:24:23.9	62.2531	7.5407	1.16	A
6	4252	12/17/90	15:44:01.8	62.2936	7.2337	1.14	A
8	10047	1/31/91	13:53:55.0	62.4133	7.3089	1.28	A

Table 6: Sorted events for area 31

Event #	IMS orid	Origin time		IMS lat.	IMS lon.	IMS ml	Group
16	25992	6/8/91	15:24:53.9	62.5132	7.6565	1.57	A
19	28428	7/4/91	16:15:09.3	62.2090	7.4522	1.61	A
21	30469	7/19/91	15:11:41.1	62.2808	7.5615	1.50	A
24	34950	8/14/91	14:00:15.4	62.1604	7.1555	1.74	A
26	38297	9/5/91	22:36:51.7	62.3531	7.6692	1.82	A
28	40465	9/18/91	21:48:17.7	62.4236	7.3846	1.69	A
36	319378	2/19/92	18:09:00.7	62.3824	7.2756	1.36	A
40	325147	4/1/92	16:56:34.2	62.2890	7.2357	1.61	A
41	324452	4/10/92	14:47:22.3	62.2681	7.4835	1.64	A
42	325511	4/22/92	18:45:54.9	62.1992	7.4185	1.51	A
44	326152	4/26/92	20:21:20.8	62.3356	6.8153	1.61	A
46	328737	5/22/92	14:55:22.3	62.5628	6.7505	1.53	A
48	333003	6/25/92	20:35:04.5	62.3223	7.1887	1.60	A
51	335212	8/6/92	06:56:48.5	62.1975	7.7111	1.15	A
53	336596	8/21/92	14:58:43.4	62.3031	7.8807	1.31	A
56	338043	9/6/92	16:45:02.8	62.3541	7.8374	1.03	A
63	340702	10/3/92	14:42:21.9	62.2837	7.8288	1.27	A
45	328569	5/21/92	12:13:52.3	62.7966	6.7777	1.62	B
52	336459	8/20/92	11:50:06.9	62.7417	6.7152	1.63	B
59	340523	9/23/92	12:44:12.2	62.5318	7.6475	1.43	B
68	342817	11/5/92	12:38:26.0	62.2263	7.5716	1.25	B
23	35150	8/9/91	14:59:48.0	62.7840	7.6879	1.49	C
34	313740	1/18/92	05:57:29.6	62.2207	7.2037	1.57	C
10	10235	2/2/91	18:41:09.9	62.3782	5.9031	2.35	D
22	31976	7/28/91	20:14:29.3	62.2162	6.3369	1.14	D

*Remarks:*

- Half of these events have very low signal-to-noise ratios.
- The other half contains mostly events from group A whose locations spread over a large area. No mines have been reported close to these locations.

*Mine and event locations:*

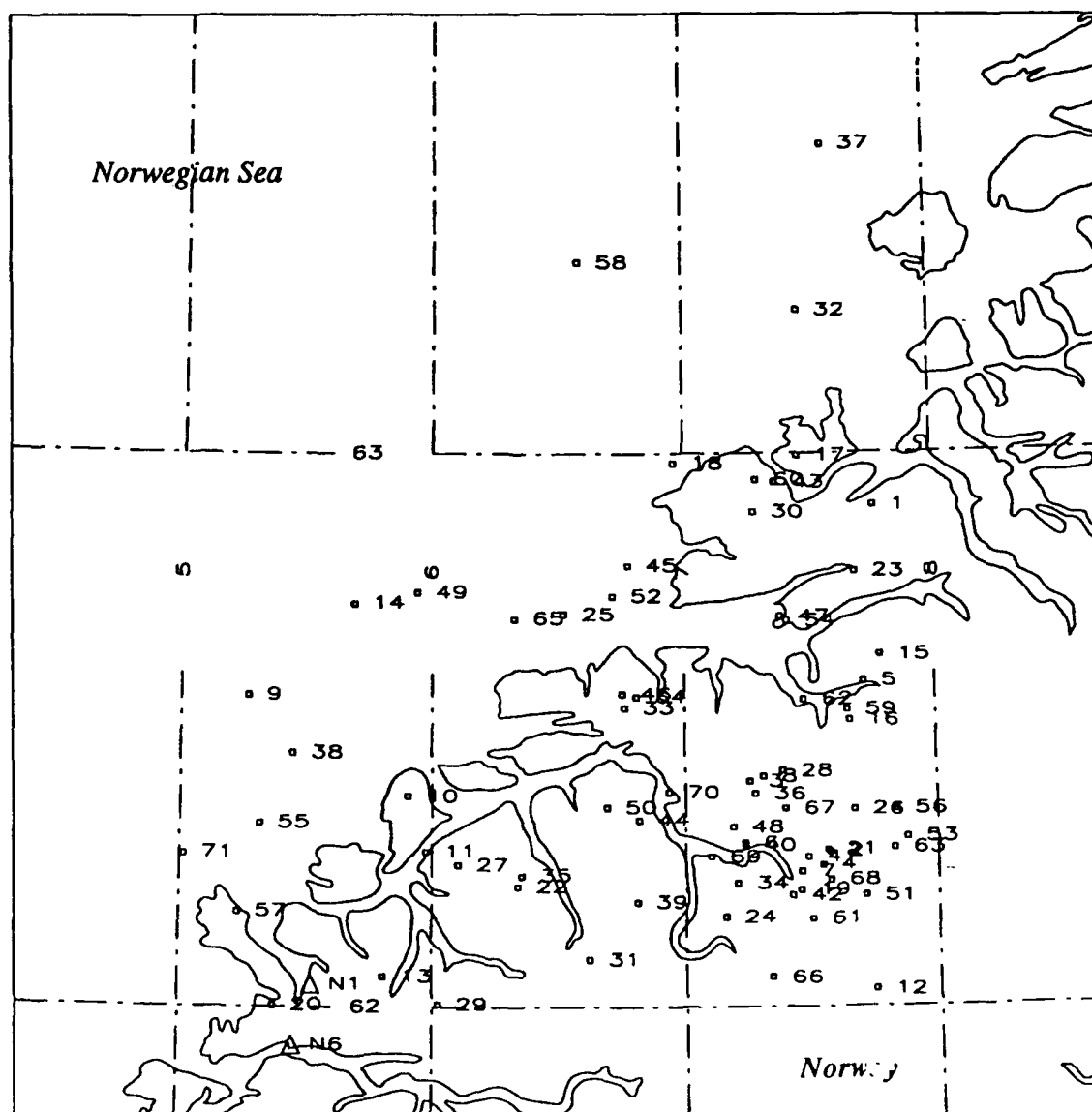


Figure 4: Mine and IMS event locations for area 31.



## AREA 32

*Latitude: 62 - 64°N*

*Longitude: 8 - 12°E*

*Local magnitude range: > 1.0*

*Number of events in IMS2: 305*

*Number of events within the magnitude range: 134*

*Number of processed events: 105*

*Frequency range used to process the data: 2 - 16 Hz*

*Processed signal length: 7s. before P, 62s. after P*

*Number of reference events: 11*

**Table 7: Reference events for area 32**

Event #	IMS orid	IMS arid	IMS wfid	Threshold	Group
23	16230	727130	554614	0.80	A
58	30943	857460	1004021	0.83	B
20	15714	717638	517697	-	C
57	30722	851430	989039	0.85	D
4	42123	542979	635977	-	E
11	13322	697403	447419	-	F
33	23076	790265	780690	0.88	G
99	341497	1469971	2767320	0.77	H
37	24467	799678	867558	-	I
89	336514	1402119	2582050	0.84	J
105	344551	1522192	2864049	0.85	K

*Reported mine locations:*

**Table 8: Mine locations for area 32**

Label	Latitude	Longitude	Origin
JOG10	62.04	10.82	JOG
JOG11	62.10	10.21	JOG
JOG12	62.10	9.80	JOG
JOG13	62.11	9.82	JOG
JOG14	62.11	9.90	JOG

**Table 8: Mine locations for area 32**

Label	Latitude	Longitude	Origin
JOG15	62.13	10.09	JOG
JOG16	62.15	10.08	JOG
JOG17	62.15	10.68	JOG
JOG18	62.28	10.32	JOG
JOG19	62.32	10.62	JOG
JOG20	62.33	10.62	JOG
JOG21	62.38	10.40	JOG
JOG22	62.38	10.42	JOG
JOG23	62.41	10.27	JOG
JOG24	62.41	10.28	JOG
JOG25	62.44	10.86	JOG
JOG26	62.44	10.87	JOG
JOG27	62.52	11.22	JOG
JOG28	62.54	11.10	JOG
JOG29	62.54	11.25	JOG
JOG30	62.55	11.81	JOG
JOG31	62.57	11.82	JOG
JOG32	62.63	11.55	JOG
JOG33	62.67	11.28	JOG
JOG34	62.69	11.28	JOG
JOG35	62.71	11.28	JOG
JOG36	62.77	11.28	JOG
JOG37	62.79	11.25	JOG
JOG38	62.81	11.26	JOG
JOG39	62.82	10.05	JOG
JOG40	62.84	11.55	JOG
JOG41	62.87	11.63	JOG
JOG42	62.92	11.68	JOG
JOG43	62.94	11.50	JOG

*Number of events found in the Helsinki bulletin: None*  
*Events with the most reliable classification:*

**Table 9: Sorted events for area 32**

Event #	IMS orid	IMS origin time		IMS lat	IMS lon	IMS ml	Group
17	14259	3/19/91	12:31:22.4	63.4953	9.3970	1.24	A
21	16827	4/3/91	07:16:53.7	63.7548	9.2443	1.60	A
23	16230	4/5/91	09:01:38.7	63.0640	8.8438	1.39	A
25	16891	4/9/91	11:19:57.9	63.2350	9.4245	1.31	A
26	17772	4/10/91	18:38:07.4	63.2591	9.6294	1.44	A
27	18752	4/18/91	07:22:42.4	63.4696	9.5131	1.53	A
31	19884	4/23/91	11:55:09.6	63.3922	9.3568	1.40	A
36	24571	5/30/91	12:15:04.2	63.6696	9.4185	1.67	A
38	25126	6/3/91	14:43:33.3	63.5047	9.4820	1.39	A
46	26136	6/12/91	17:52:02.1	63.2744	9.5871	1.37	A
75	301345	11/4/91	15:04:35.9	63.8362	9.6451	1.46	A
76	302993	12/18/91	14:05:34.4	63.6997	9.4698	1.57	A
41	25709	6/6/91	02:14:40.0	63.4018	8.9992	1.42	B
51	28749	7/2/91	19:32:05.5	63.6677	9.2719	1.44	B
53	29867	7/11/91	10:39:51.8	63.4345	9.1061	1.20	B
56	30614	7/16/91	15:09:57.3	63.5818	9.3324	1.15	B
58	30943	7/23/91	09:11:07.8	63.2602	9.3484	1.27	B
61	33460	8/2/91	15:42:44.4	63.6157	9.0001	1.50	B
63	34406	8/8/91	09:08:55.5	63.2902	9.0609	1.27	B
68	35047	8/15/91	17:47:55.4	63.4197	9.2668	1.28	B
70	37073	8/29/91	18:44:55.8	63.3012	8.9277	1.19	B
72	39663	9/11/91	16:27:31.1	63.2599	9.0554	1.27	B
73	39930	9/18/91	18:07:32.7	63.2313	8.4347	1.12	B
81	324155	3/25/92	15:42:31.9	63.3540	9.3956	1.17	B
12	13522	3/7/91	15:18:57.2	63.5109	9.4243	1.40	C
15	14396	3/13/91	14:42:09.0	63.2046	8.8618	1.27	C
16	15276	3/18/91	16:07:32.9	63.4951	9.1985	1.41	C

Table 9: Sorted events for area 32

Event #	IMS orid	IMS origin time		IMS lat	IMS lon	IMS ml	Group
20	15714	3/27/91	09:51:41.0	63.3365	9.6751	1.51	C
22	16542	4/4/91	19:02:35.2	63.3251	9.1368	1.17	C
24	17329	4/8/91	15:10:35.8	63.2274	8.9803	1.28	C
28	18386	4/19/91	14:09:28.6	63.4639	8.3145	1.32	C
30	19758	4/22/91	19:05:02.2	63.3100	9.0492	1.26	C
32	19314	4/25/91	15:58:43.8	63.3341	9.2370	1.26	C
34	23536	5/24/91	10:48:06.7	63.2894	8.2568	1.29	C
35	23637	5/24/91	19:24:39.7	63.3163	8.9348	1.01	C
40	25301	6/3/91	20:40:15.5	63.3768	9.0798	1.29	C
47	26259	6/13/91	16:05:45.4	63.6499	8.8450	1.64	C
52	29490	7/9/91	19:53:13.1	63.7328	9.4723	1.50	D
54	29880	7/11/91	21:51:15.5	63.4808	9.1924	1.37	D
55	29966	7/16/91	13:48:14.2	63.3238	9.2981	1.30	D
57	30722	7/18/91	15:51:23.0	63.6993	9.4990	1.37	D
60	32312	7/30/91	13:17:42.1	63.3700	9.4297	1.29	D
4	42123	12/4/90	11:17:54.5	63.2156	11.0211	1.12	E
11	13322	3/6/91	15:22:06.6	63.3378	10.4514	1.17	E
5	42203	12/5/90	10:07:15.9	62.9914	8.3237	1.34	F
6	42262	12/6/90	10:42:45.7	62.8699	8.5054	1.30	F
33	23076	5/21/91	14:55:34.7	62.7600	8.6713	1.04	G
42	25990	6/8/91	14:24:38.4	62.8022	8.0360	1.27	G
39	25127	6/3/91	15:03:11.9	63.2008	10.5989	1.09	H
48	26559	6/17/91	17:16:35.0	63.2677	11.0273	1.05	H
65	35417	8/12/91	13:59:19.3	63.1807	10.9654	1.00	H
87	333068	7/3/92	11:31:33.5	63.2195	11.7209	1.03	H
90	337287	8/28/92	13:48:07.7	62.8906	10.8331	1.02	H
91	337566	9/1/92	12:21:04.2	63.3407	11.4751	1.13	H
93	337898	9/4/92	15:12:45.1	63.0940	11.3602	1.19	H
95	340547	9/23/92	15:22:26.6	63.1116	11.0033	1.19	H
99	341497	10/16/92	15:45:32.1	63.3674	11.4088	1.45	H

**Table 9: Sorted events for area 32**

Event #	IMS orid	IMS origin time		IMS lat	IMS lon	IMS ml	Group
100	341497	10/16/92	15:45:32.1	63.3674	11.4088	1.45	H
37	24467	5/31/91	11:55:45.3	62.6956	10.5410	1.23	I
45	26064	6/12/91	16:42:59.5	62.6889	10.3887	1.00	I
13	13533	3/7/91	19:49:31.5	62.3631	9.3006	1.20	J
69	36745	8/28/91	18:44:45.5	62.1535	9.4477	1.65	J
89	336514	8/20/92	18:46:22.6	62.2988	9.4481	1.37	J
94	338572	9/11/92	18:47:25.0	62.1476	9.4034	1.13	J
97	341003	10/8/92	19:50:49.0	62.1118	9.4146	1.13	J
101	341508	10/16/92	19:42:29.7	62.1295	9.4369	1.20	J
1	1501	11/5/90	19:48:31.6	62.1338	9.4278	1.05	K
2	2672	11/16/90	19:42:52.3	62.1856	9.5278	1.04	K
3	10069	11/29/90	19:46:28.4	62.1950	9.3288	1.04	K
7	3527	12/10/90	19:49:07.3	62.1198	9.4047	1.18	K
8	314343	12/19/90	19:50:08.2	62.2152	9.1472	1.07	K
10	8464	1/22/91	19:51:39.0	62.3048	9.1366	1.29	K
14	14294	3/12/91	19:45:18.7	62.2959	9.2940	1.05	K
49	28964	7/4/91	18:43:24.3	62.4489	9.0456	1.12	K
64	35163	8/9/91	22:08:37.4	62.1405	9.4843	1.05	K
71	37722	9/3/91	18:47:13.0	62.2613	9.8207	1.02	K
74	41735	9/26/91	18:41:23.8	62.1319	9.3922	1.11	K
77	319330	2/18/92	19:43:04.8	62.3007	9.3076	1.02	K
84	325933	4/24/92	18:43:25.8	62.1619	9.5347	1.19	K
86	330386	6/12/92	18:45:16.5	62.1517	9.4967	1.39	K
96	340179	9/25/92	18:39:33.6	62.2494	9.9568	1.35	K
103	343116	11/9/92	19:46:13.0	62.2124	9.5659	1.06	K
105	344551	11/27/92	19:38:27.1	62.0900	9.4424	1.08	K

*Remarks:*

- Events from groups A, B, C and D are concentrated in an area located on the North-western part of the map (Figure 5) where no mines have been reported.
- Events from groups J and K form a tight cluster in the southern part of the map

whose location is the closest to a reported mine.

- The location of seismic activity does not correspond to the locations of the reported mines in this area.

*Mine and event locations:*

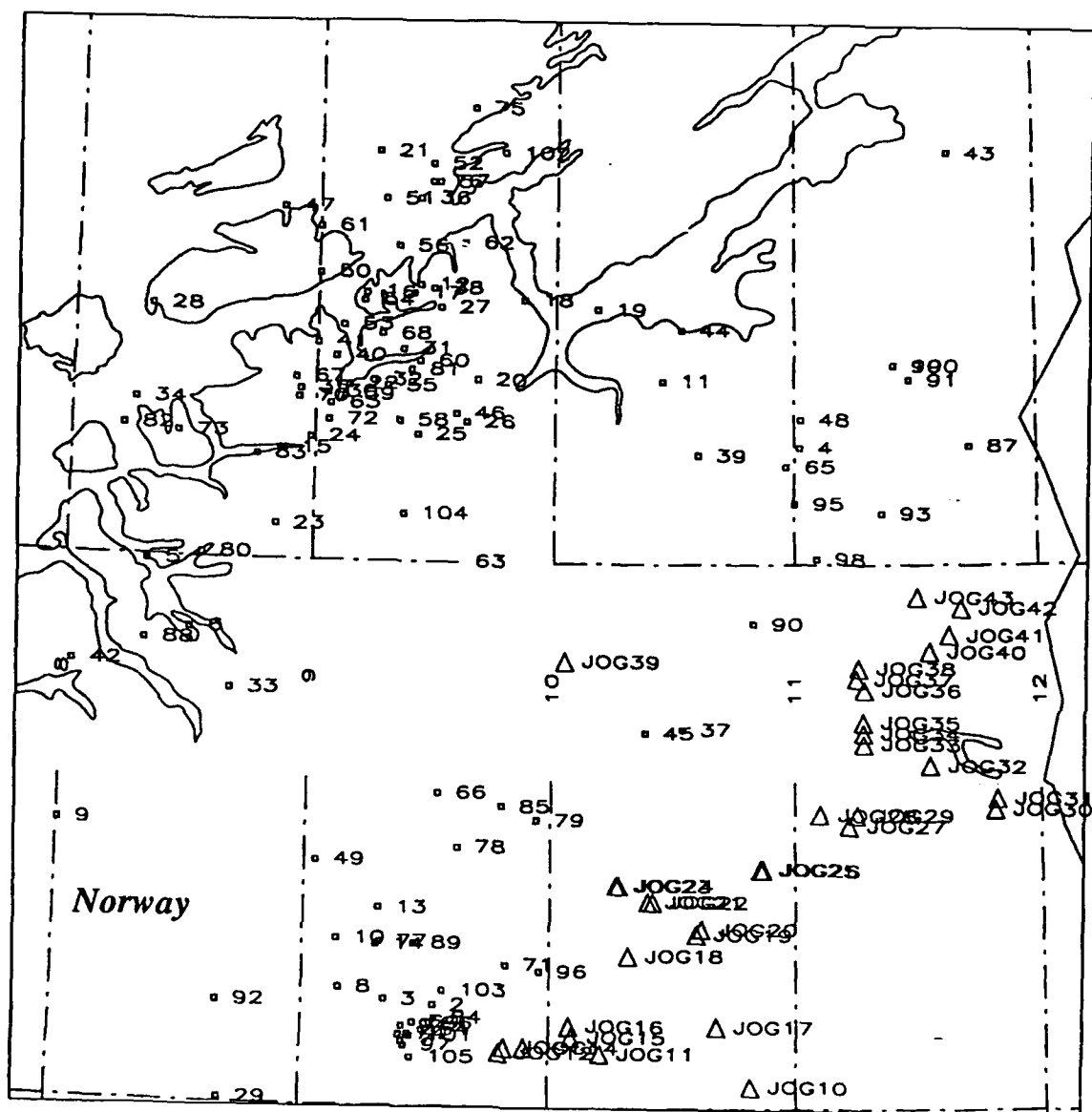


Figure 5: Mine and IMS event locations for area 32.



## AREA 33

*Latitude: 62 - 64°N*

*Longitude: 12 - 18°E*

*Local magnitude range: -*

*Number of events in IMS2: 43*

*Number of events within the magnitude range: 43*

*Number of processed events: 34*

*Frequency range used to process the data: 3.5 - 14 Hz*

*Processed signal length: 10s. before P, 90s. after*

*Number of reference events: 1*

**Table 10: Reference events for area 33**

Event #	IMS orid	IMS arid	IMS wfid	Threshold	Group
7	15103	710967	498323	0.87	A

*Reported mine locations: None*

*Number of events found in the Helsinki bulletin: 1*

**Table 11: Events found in the Helsinki bulletin for area 33**

Event #	IMS orid	IMS origin time		IMS ml	HEL location		HEL label	Group
17	302895	12/15/91	15:18:47.5	2.74	62.15	17.61	EART.	-

*Events with the most reliable classification:*

**Table 12: Sorted events for area 33**

Event #	IMS orid	IMS origin time		IMS lat	IMS lon	IMS ml	Group
5	14927	3/19/91	13:04:20.1	62.7520	17.9256	1.68	A
7	15103	3/20/91	10:55:56.0	62.7197	17.9496	1.57	A
8	15237	3/21/91	11:57:16.4	62.6679	17.9993	1.78	A

*Remarks:*

- Most of these events have very low signal-to-noise ratios and could not be sorted. However, the locations spread over the whole area which implies that most of these events are probably unique.
- A small group of three events corresponding to group A can be seen on the Eastern part of the map (Figure 6).

*Mine and event locations:*

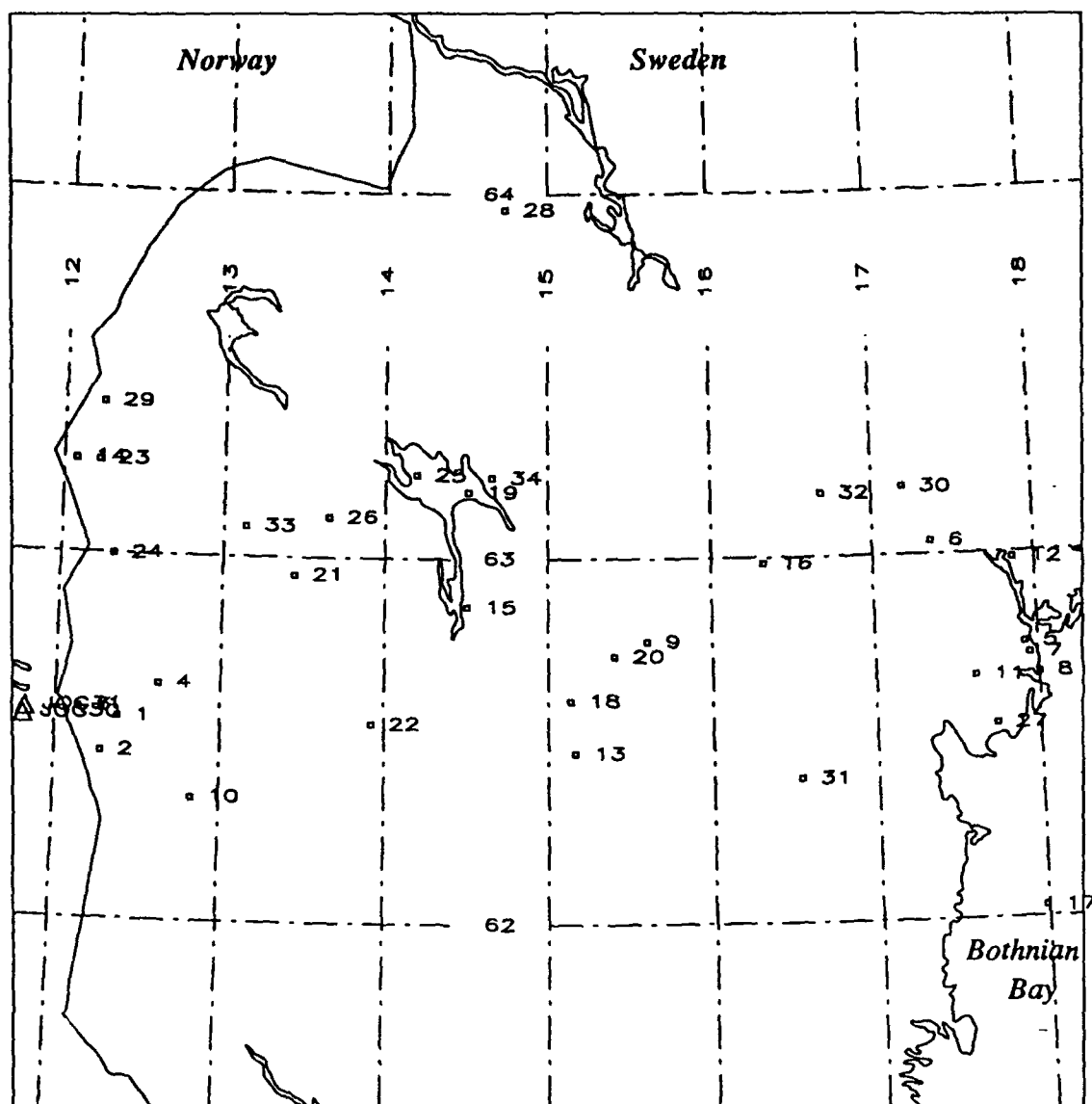


Figure 6: IMS event locations for area 33

## AREA 34

*Latitude: 62 - 64°N*

*Longitude: 18 - 24°E*

*Local magnitude range: > 1.0*

*Number of events in IMS2: 395*

*Number of events within the magnitude range: 83*

*Number of processed events: 9*

*Frequency range used to process the data: 3.5 - 16 Hz*

*Processed signal length: 14s. before P, 134s. after P*

*Number of reference events: None*

*Reported mine locations:*

**Table 13: Mine locations for area 34**

Label	Latitude	Longitude	Origin
HM14	62.8	22.9	Hels
HM20	62.7	23.2	Hels
HM21	62.6	23.6	Hels
N218	63.8667	20.2167	Norw
N215	63.9167	20.1000	Norw
N219	63.9167	20.3000	Norw
N217	63.9333	20.0667	Norw

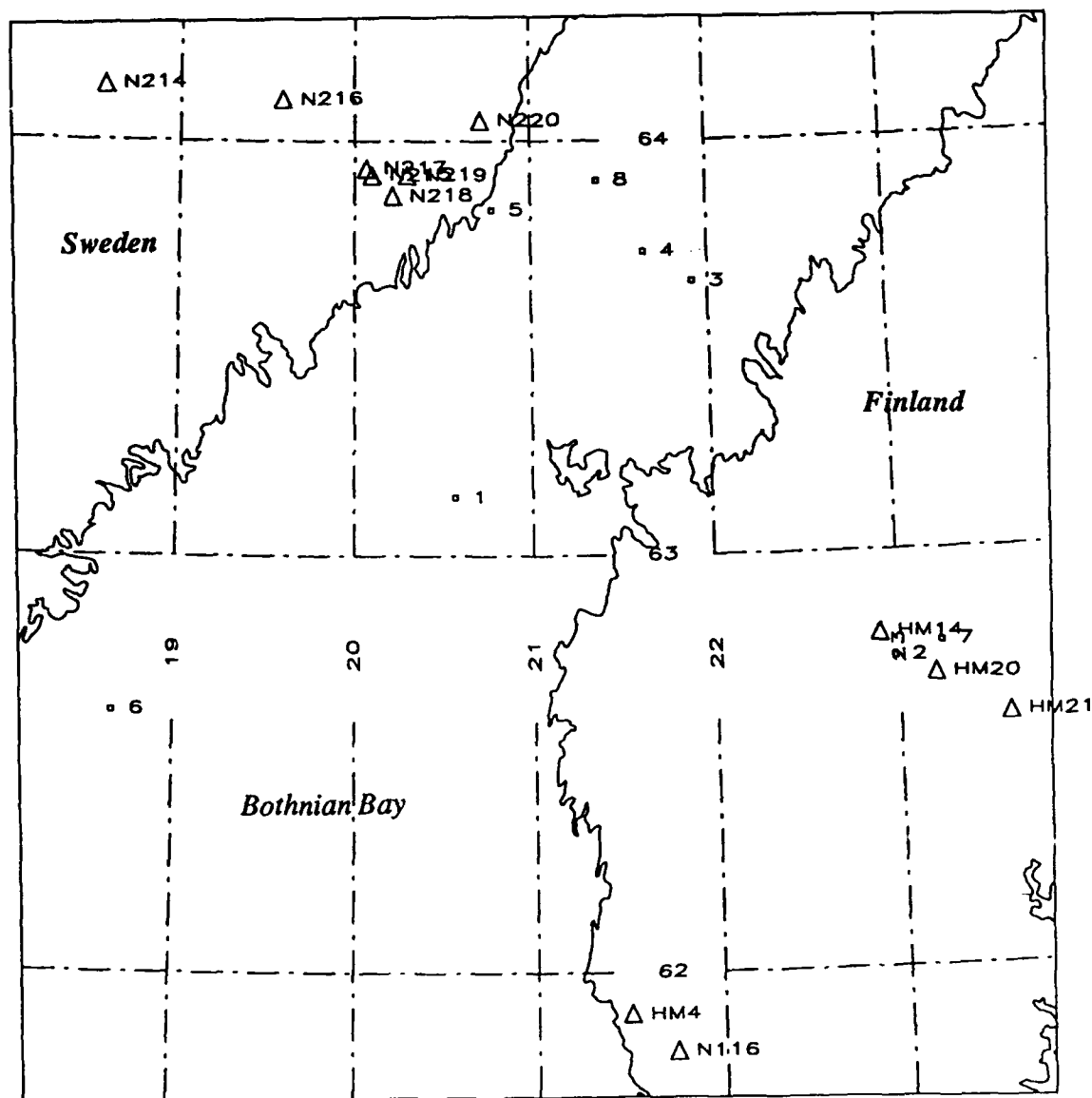
*Number of events found in the Helsinki bulletin: 6*

**Table 14: Events found in the Helsinki bulletin**

Event #	IMS orid	IMS origin time		IMS ml	HEL location		HEL label	Group
1	25858	6/7/91	07:32:56.0	1.66	63.38	21.01	-	-
2	27857	6/27/91	11:44:55.0	1.61	62.82	22.89	-	-
3	300451	10/21/91	13:04:12.9	1.72	63.57	21.57	-	-
4	300450	10/21/91	13:05:20.5	1.72	63.60	21.33	-	-
5	300864	10/28/91	16:21:27.1	2.15	64.06	19.92	P.E.	-
8	330462	5/22/92	23:06:27.3	2.71	63.8700	21.32	P.E.	-

- Most of these events are located in the Bothnian Bay, including two events identified in the Helsinki bulletin as being "probably earthquakes".

**Mine and event locations:**



**Figure 7: Mine and IMS event locations for area 34**

## AREA 46

*Latitude:* 60 - 62°N

*Longitude:* 16 - 20°E

*Local magnitude range:* -

*Number of events in IMS2:* 44

*Number of events within the magnitude range:* 44

*Number of processed events:* 31

*Frequency range used to process the data:* 3.5 - 16 Hz

*Processed signal length:* 9s. before P, 84s. after P

*Number of reference events:* None

*Reported mine locations:*

**Table 15: Mine locations for area 46**

Label	Latitude	Longitude	Origin
N202	60.120	17.520	Norw
N204	60.185	16.115	Norw
N203	60.200	16.130	Norw

*Number of events found in the Helsinki bulletin:* None

*Remarks:*

- The distribution of the event locations reflects the diversity of the signals and explains the absence of reference events.

*Mine and event locations:*

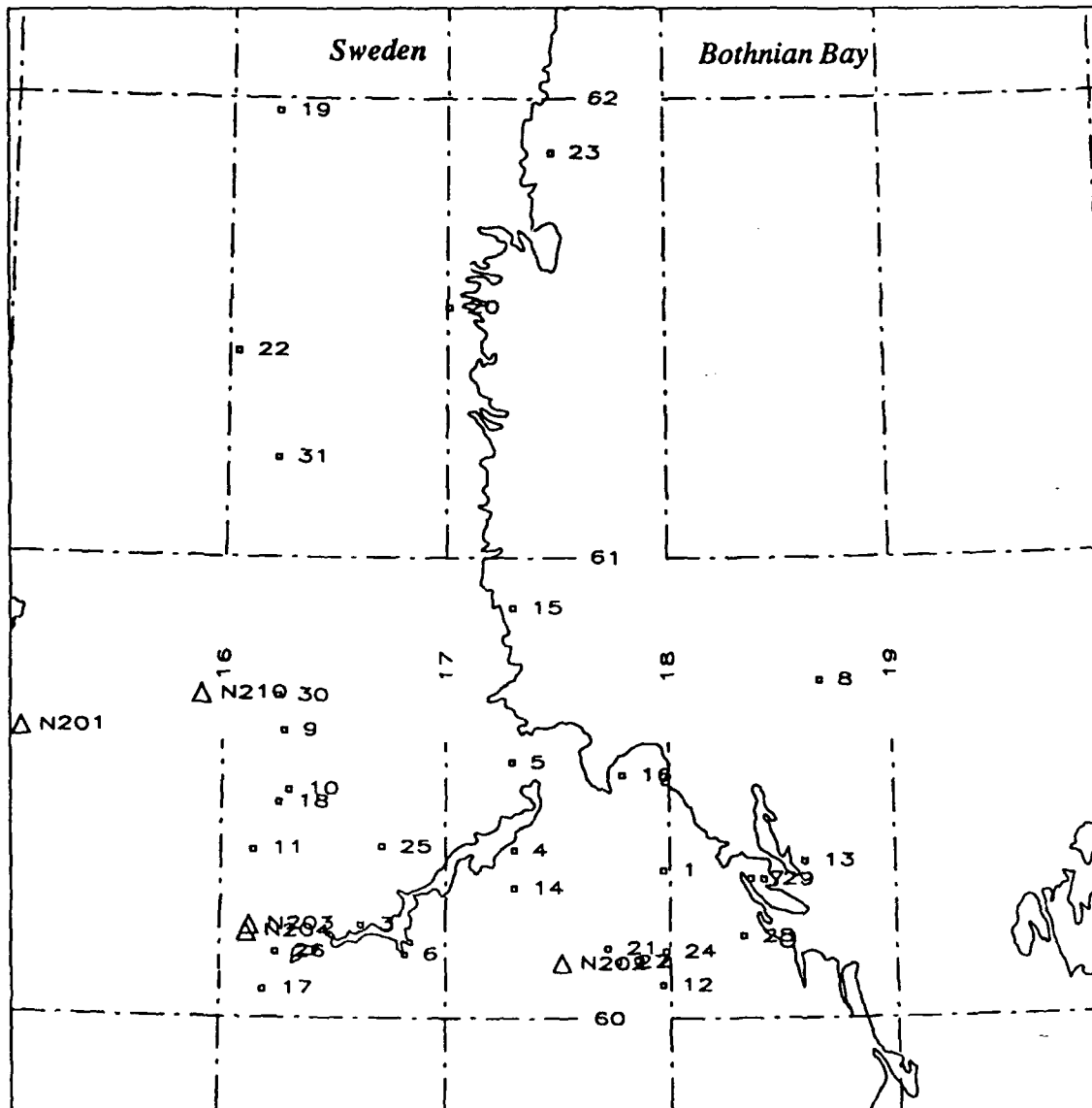


Figure 8: Mine and IMS event locations for area 46.

## AREA 47

*Latitude: 60 - 62°N*

*Longitude: 12 - 16°E*

*Local magnitude range: 1.0*

*Number of events in IMS2: 272*

*Number of events within the magnitude range: 110*

*Number of processed events: 91*

*Frequency range used to process the data: 2 - 16 Hz*

*Processed signal length: 4s. before P, 39s. after P*

*Number of reference events: 8*

**Table 16: Reference events for area 47**

Event #	IMS orid	IMS arid	IMS wfid	Threshold	Group
3	42282	545254	639181	0.82	A
30	37296	924183	1200628	0.82	B
59	319726	1207183	1771113	0.84	C
57	302795	1010631	1504009	0.86	D
40	41425	959796	1274813	0.84	E
11	28037	820226	931865	0.92	F
15	28391	828812	944111	0.87	G
81	332016	1324336	2222884	0.90	H

*Reported mine locations:*

**Table 17: Mine locations for area 47**

Label	Latitude	Longitude	Origin
N207	60.10	15.00	Norw
N201	60.62	15.10	Norw
N210	60.70	15.90	Norw

*Number of events found in the Helsinki bulletin: None*

*Events with the most reliable classification:*

**Table 18: Sorted events for area 47**

Event #	OMS orid	IMS origin time		IMS lat	IMS lon	IMS ml	Group
1	3004	11/21/90	13:46:49.8	60.1311	15.3008	1.16	A
3	42282	12/6/90	14:42:26.9	60.2175	15.3287	1.46	A
7	23390	5/23/91	12:58:53.6	60.7785	15.6215	1.32	A
20	28599	7/3/91	12:49:54.6	60.4589	15.4166	1.12	A
24	34925	8/14/91	11:35:12.4	60.2610	15.3440	1.18	A
60	320206	3/11/92	13:29:30.4	60.1714	15.2612	1.36	A
68	329110	5/27/92	10:38:29.7	61.0472	15.3701	1.17	A
87	341879	10/21/92	11:39:50.6	61.1989	15.3446	1.13	A
2	3093	12/4/90	13:03:52.8	60.4271	15.4105	1.12	B
4	4376	12/19/90	13:39:21.9	60.2553	15.3392	1.40	B
6	18168	4/18/91	08:56:31.3	60.9955	15.3597	1.04	B
30	37296	9/4/91	08:31:06.2	61.0303	15.2741	1.14	B
90	344341	11/26/92	11:25:42.1	61.1694	15.4875	1.16	B
5	17430	4/9/91	09:34:50.7	60.9651	15.3808	1.10	C
59	319726	3/4/92	11:06:43.0	61.0102	15.3852	1.10	C
64	327210	5/7/92	09:18:49.5	60.9830	15.3683	1.33	C
67	328433	5/20/92	14:00:28.7	61.0060	15.3720	1.11	C
69	330106	6/10/92	09:08:19.7	61.0085	15.1856	1.23	C
84	336291	8/19/92	08:54:29.9	61.0261	15.3019	1.20	C
88	342778	11/3/92	10:34:39.2	61.0936	15.4070	1.12	C
91	347161	1/5/93	09:41:39.7	61.0316	15.3004	1.02	C
57	302795	12/6/91	12:27:33.2	60.3073	15.8303	1.45	D
66	327908	5/15/92	09:32:13.0	60.0728	15.6417	1.02	D
89	343101	11/9/92	13:36:25.9	60.2572	15.8857	1.31	D
23	35243	8/10/91	07:58:49.9	60.5638	15.3543	1.13	E
40	41425	9/29/91	10:59:38.7	60.7755	15.3188	1.08	E
55	301532	11/14/91	12:37:16.6	60.9911	15.3022	1.00	E
56	301912	11/21/91	10:29:11.5	60.9822	15.4179	1.03	E

Table 18: Sorted events for area 47

Event #	OMS orid	IMS origin time		IMS lat	IMS lon	IMS ml	Group
58	302686	12/11/91	08:00:33.4	60.9863	15.3465	1.01	E
61	320361	3/12/92	11:05:17.0	61.0543	15.3888	1.36	E
8	27706	6/17/91	13:29:59.8	61.5062	13.7830	1.52	F
9	27661	6/18/91	08:24:58.0	61.5178	13.9398	1.36	F
10	27952	6/18/91	12:45:10.5	61.5884	13.8180	1.49	F
11	28037	6/25/91	16:45:16.5	61.5420	13.8613	1.49	F
12	28324	6/26/91	14:30:17.7	61.4896	13.9075	1.49	F
14	27438	6/27/91	14:00:33.8	61.4740	13.9816	1.54	F
16	28020	7/1/91	14:00:05.8	61.5161	13.8931	1.52	F
18	28714	7/2/91	14:00:23.8	61.5444	13.8976	1.43	F
27	36697	8/28/91	09:29:50.6	61.4751	13.9248	1.38	F
36	41589	9/25/91	07:46:53.2	61.5585	14.0371	1.48	F
38	41689	9/26/91	09:44:47.6	61.6377	13.6103	1.49	F
41	300083	10/1/91	09:03:40.8	61.5026	13.8868	1.48	F
42	300096	10/1/91	13:00:17.2	61.4871	13.8676	1.36	F
43	300136	10/2/91	10:30:03.7	61.4223	13.8122	1.44	F
45	300454	10/21/91	13:30:03.3	61.5278	13.9385	1.45	F
46	300474	10/21/91	17:01:10.2	61.4714	13.8611	1.41	F
48	300634	10/22/91	14:00:14.0	61.4806	14.0205	1.52	F
49	300637	10/22/91	17:45:13.9	61.5579	13.7215	1.54	F
50	300861	10/28/91	14:30:03.2	61.6715	13.6322	1.45	F
51	300876	10/29/91	09:00:31.4	61.4382	14.0326	1.46	F
52	300886	10/29/91	12:30:01.3	61.4972	13.7930	1.54	F
53	300899	10/29/91	14:48:00.3	61.4306	13.9299	1.55	F
70	330661	6/16/92	09:00:03.8	61.4971	13.9021	1.46	F
71	330884	6/17/92	08:59:46.5	61.4944	13.8319	1.38	F
72	330931	6/17/92	13:30:08.1	61.4781	13.8870	1.47	F
73	330980	6/18/92	08:59:54.1	61.5160	13.8661	1.46	F
74	331304	6/22/92	13:29:53.0	61.5151	13.8992	1.46	F
75	331366	6/23/92	09:06:34.6	61.6681	13.7965	1.43	F

**Table 18: Sorted events for area 47**

Event #	OMS orid	IMS origin time		IMS lat	IMS lon	IMS ml	Group
77	331496	6/24/92	09:00:07.1	61.6547	13.7685	1.56	F
78	331583	6/25/92	09:00:09.6	61.4658	13.8716	1.55	F
79	331899	6/29/92	12:00:01.7	61.4819	13.8264	1.32	F
80	331994	6/30/92	09:30:29.3	61.5306	13.8540	1.38	F
82	332169	7/2/92	07:05:19.8	61.4618	13.7778	1.34	F
83	332183	7/2/92	09:05:08.4	61.5278	13.9221	1.30	F
13	27842	6/27/91	09:29:58.3	61.5724	13.8323	1.51	G
15	28391	7/1/91	09:29:49.5	61.4759	13.8875	1.50	G
17	28564	7/2/91	09:29:56.5	61.4779	13.9309	1.49	G
19	28592	7/3/91	09:30:21.0	61.5030	13.7669	1.38	G
21	28282	7/3/91	14:30:21.8	61.5463	13.8288	1.36	G
22	28937	7/4/91	09:29:51.8	61.4820	13.9215	1.41	G
25	36905	8/27/91	13:45:01.5	61.4479	13.8925	1.06	G
26	36912	8/27/91	17:29:51.0	61.5059	13.8042	1.18	G
28	36735	8/28/91	14:29:51.5	61.5162	13.7898	1.47	G
29	37692	9/3/91	10:14:50.7	61.5523	13.7802	1.32	G
31	37366	9/4/91	14:00:02.8	61.4724	13.7358	1.29	G
32	38161	9/5/91	09:45:01.1	61.5241	13.8125	1.26	G
34	41264	9/23/91	11:29:17.9	61.5324	13.8737	1.47	G
35	41529	9/23/91	16:00:14.3	61.5328	13.8973	1.51	G
37	41659	9/25/91	14:59:55.2	61.5309	13.9606	1.43	G
39	41726	9/26/91	13:53:14.7	61.4908	13.8912	1.34	G
44	300152	10/2/91	15:00:17.5	61.5757	13.6974	1.54	G
47	300529	10/22/91	10:00:12.0	61.5952	13.6760	1.53	G
54	300916	10/30/91	09:15:07.8	61.5933	13.7689	1.34	G
81	332016	6/30/92	11:33:51.7	60.9237	14.9131	1.12	H
86	339558	9/22/92	13:28:01.5	61.0327	14.8778	1.39	H

**Remarks:**

- Events from groups G and H are located North of the map (Figure 9) forming a tight cluster of events.

- Another cluster is located on the eastern part of the map and consists of events from groups B and C.
- None of these clusters is located close to one of the three reported mines.

*Mine and event locations:*

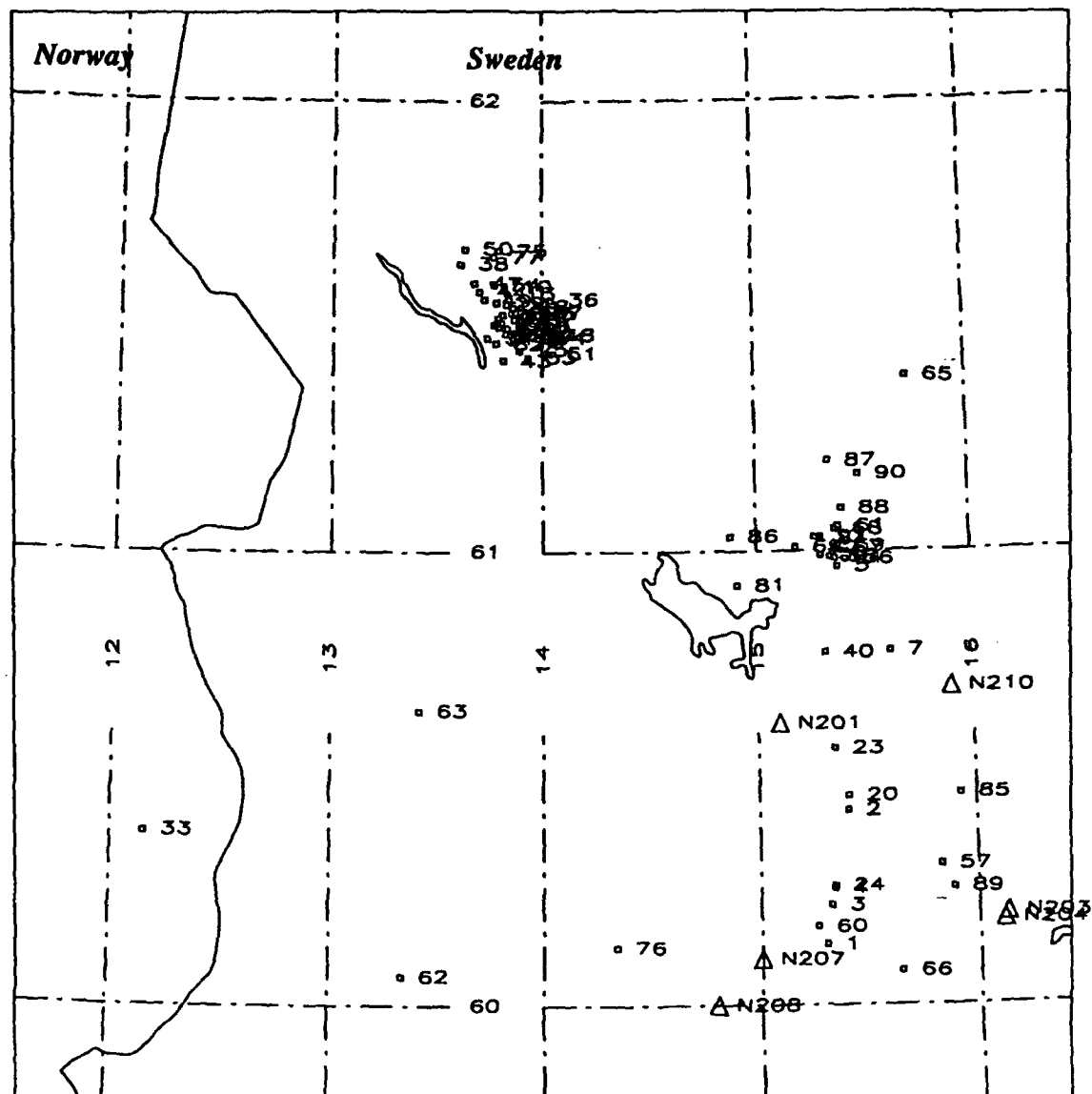


Figure 9: Mine and IMS event locations for area 47.



## AREA 48

*Latitude: 60 - 62°N*

*Longitude: 8 - 12°E*

*Local magnitude range: 0.8*

*Number of events in IMS2: 808*

*Number of events within the magnitude range: 133*

*Number of processed events: 109*

*Frequency range used to process the data: 2 - 16 Hz*

*Processed signal length: 4s. before P, 34s. after P*

*Number of reference events: 17*

**Table 19: Reference events for area 48**

Event #	IMS orid	IMS arid	IMS wfid	Threshold	Group
16	24385	797972	817722	0.83	A
54	312991	1030806	1605961	0.84	B
75	326308	1237047	1996500	0.90	C
46	301900	1007830	1467526	-	D
63	316161	1193338	1723863	0.83	E
21	26053	809671	901791	-	F
12	22723	784915	766053	0.87	G
109	345726	1536489	2886318	0.85	H
41	301216	1005791	1410322	-	I
91	334304	1328018	2275159	0.87	J
96	336330	1401620	2487487	0.82	K
39	300941	1003333	1348130	-	L
87	331611	1320677	2203294	0.86	M
6	7911	596037	427058	-	N
71	323262	1228970	1876932	0.82	O
9	19495	756378	709602	0.83	P
2	3215	530595	593995	-	Q
7	11084	619680	1375873	-	R

*Reported mine locations:*

**Table 20: Mine locations for area 48**

Label	Latitude	Longitude	Origin
N13	60.74	11.02	Norw

*Number of events found in the Helsinki bulletin: 1*

**Table 21: Events found in the Helsinki bulletin for area 48**

Event #	IMS orid	IMS origin time		IMS ml	HEL location		HEL label	Group
88	333032	6/30/92	15:04:38.3	2.05	60.88	11.44	PE.	-

*Events with the most reliable classification:*

**Table 22: Sorted events for area 48**

Event #	IMS orid	IMS origin time		IMS lat	IMS lon	IMS ml	Group
8	18722	4/15/91	15:02:41.4	61.2648	10.5470	0.85	A
11	22203	5/13/91	19:06:09.2	61.1453	10.4847	1.31	A
13	22725	5/14/91	19:10:19.4	61.1784	10.6462	1.02	A
15	24176	5/28/91	18:03:40.4	61.2074	10.6158	1.20	A
16	24385	5/29/91	19:09:37.1	61.0957	10.6542	1.32	A
18	25754	6/6/91	15:00:05.8	61.2133	10.4028	1.49	A
20	25897	6/7/91	13:00:11.7	61.2539	10.5088	0.94	A
25	28613	7/3/91	18:14:58.6	61.2528	10.4618	1.24	A
26	28954	7/4/91	13:13:45.9	61.2170	10.5436	1.12	A
28	29375	7/10/91	13:32:42.9	61.1259	10.7449	0.84	A
42	301552	11/15/91	15:17:56.3	61.4586	10.2080	0.84	A
43	301917	11/21/91	10:37:09.2	61.1874	10.5110	1.13	A
45	302028	11/27/91	14:01:39.7	61.2248	10.5023	1.09	A
48	302193	12/9/91	14:03:59.6	61.1600	10.7332	1.08	A
49	302751	12/5/91	14:05:13.0	61.2747	10.4371	0.91	A
50	302574	12/11/91	11:56:52.3	61.3662	10.2765	1.08	A
57	312784	1/14/92	14:05:31.0	61.0408	10.3954	0.98	A

Table 22: Sorted events for area 48

Event #	IMS orid	IMS origin time		IMS lat	IMS lon	IMS ml	Group
58	313666	1/16/92	14:14:07.3	61.1599	10.2926	0.81	A
19	25872	6/7/91	10:58:56.6	60.3179	11.1898	0.81	B
29	32920	7/31/91	12:14:59.1	60.2087	11.0730	0.84	B
32	38259	9/5/91	17:18:21.0	60.2730	11.1342	1.22	B
33	40185	9/17/91	17:04:12.4	60.2728	11.1299	0.86	B
35	41662	9/25/91	15:46:11.3	60.2775	11.1581	0.91	B
37	300633	10/22/91	13:10:26.1	60.3078	11.1631	1.13	B
38	300936	10/30/91	12:46:36.5	60.3375	11.2087	0.91	B
40	301232	11/12/91	13:04:28.3	60.2556	11.1215	0.85	B
47	302317	11/26/91	12:21:33.1	60.3486	11.1826	0.84	B
52	302599	12/13/91	12:48:58.0	60.3770	11.2389	1.13	B
53	302903	12/16/91	12:05:42.7	60.3612	11.2149	0.91	B
54	312991	12/30/91	12:23:23.1	60.3296	11.1668	1.11	B
55	313130	1/13/92	12:32:17.6	60.3150	11.3130	0.89	B
60	315381	1/31/92	13:53:03.8	60.3160	11.1681	0.99	B
61	315664	2/3/92	13:16:31.6	60.3387	11.1807	0.94	B
64	317816	2/20/92	12:18:38.7	60.3369	11.1646	0.97	B
74	326190	4/27/92	09:55:57.1	60.3427	11.1999	0.93	C
75	326308	4/28/92	11:24:09.7	60.3612	11.2132	1.23	C
76	326918	5/4/92	11:13:10.6	60.3373	11.1984	0.92	C
78	328207	5/18/92	12:24:22.8	60.3710	11.2074	1.13	C
79	329137	5/27/92	13:33:34.8	60.3681	11.2077	0.98	C
81	329653	6/3/92	10:59:26.3	60.3431	11.1912	0.96	C
46	301900	11/28/91	12:52:49.9	60.1047	10.3421	0.89	D
56	312179	1/13/92	14:07:19.5	60.2132	10.1051	0.82	D
63	316161	2/19/92	14:46:46.1	60.3624	9.4056	1.04	E
66	319293	2/25/92	13:32:15.1	60.3930	9.4451	0.90	E
68	320556	3/13/92	13:39:13.9	60.3932	9.4593	1.09	E

Table 22: Sorted events for area 48

Event #	IMS orid	IMS origin time		IMS lat	IMS lon	IMS ml	Group
21	26053	6/10/91	12:42:38.7	60.0366	10.7580	0.87	F
77	327524	5/11/92	14:12:46.6	60.0206	10.7158	0.80	F
12	22723	5/14/91	12:35:00.7	60.1372	11.7534	0.92	G
23	27663	6/18/91	09:08:35.1	60.1750	11.7781	1.02	G
3	4358	12/19/90	12:40:34.8	60.8386	9.3781	0.96	H
62	315818	2/18/92	15:29:29.1	60.9518	9.3670	1.06	H
109	345726	12/17/92	13:54:20.7	60.9401	8.8375	1.12	H
41	301216	11/14/91	10:46:09.7	61.8894	8.9904	1.19	I
59	315282	1/30/92	13:50:07.0	61.6813	9.5791	1.16	I
72	325494	4/22/92	15:16:10.2	61.0467	8.8891	0.88	J
89	332511	7/6/92	17:34:17.2	61.0597	8.9298	1.09	J
91	334304	7/13/92	17:18:52.0	61.0516	8.8627	0.88	J
93	334710	7/30/92	13:13:26.5	61.0602	8.8865	0.85	J
10	21003	5/7/91	12:53:22.6	60.0095	10.9706	0.86	K
96	336330	8/19/92	12:32:16.1	60.0085	10.9927	1.34	K
106	344302	11/25/92	15:57:09.1	60.0100	11.0593	0.86	K
39	300941	10/30/91	15:15:44.0	61.1108	9.2431	1.06	L
99	337682	9/2/92	14:19:45.5	61.0778	8.9359	0.96	L
67	320403	3/12/92	15:08:14.8	60.5412	8.2409	1.09	M
87	331611	6/25/92	12:47:30.4	60.5272	8.2797	0.90	M
103	341856	10/22/92	14:17:29.6	60.4436	8.4587	0.91	M
6	7911	1/24/91	14:08:33.2	60.0090	10.9210	1.23	N
14	23980	5/24/91	11:12:20.1	60.9566	10.6360	0.87	N
70	323059	3/31/92	08:46:51.2	60.5130	10.6285	0.91	O
71	323262	3/31/92	16:46:29.5	60.5183	10.6570	1.45	O
101	338792	9/14/92	12:05:54.0	60.4640	10.6949	1.50	O
9	19495	4/26/91	15:46:15.4	60.8702	11.0126	0.90	P
27	28963	7/4/91	18:03:34.0	60.8483	11.0473	0.92	P

**Table 22: Sorted events for area 48**

Event #	IMS orid	IMS origin time		IMS lat	IMS lon	IMS ml	Group
44	301948	11/21/91	15:15:53.9	60.9175	11.0433	1.34	P
2	3215	11/20/90	15:04:38.7	60.9266	11.0344	0.93	Q
34	40436	9/18/91	11:43:04.4	61.7796	9.8422	1.27	Q
7	11084	2/5/91	13:18:01.7	60.1915	10.5819	0.80	R
83	329701	6/3/92	14:07:22.6	60.1090	10.2355	0.89	R

**Remarks:**

- In this area, several groups include only two or three events.
- Two clusters of events can be seen on the map (Figure 10). One is located North of the Mojsa lake and consists of events from group A while the other cluster is located south of the lake and includes events from groups B and C.
- The single reported mine is located in the middle of the lake and the closest cluster of events (group P and Q) is about 20 km away.



## AREA 49

*Latitude: 60 - 62°N*

*Longitude: 4 - 8°E*

*Local magnitude range: 1.3*

*Number of events in IMS2: 776*

*Number of events within the magnitude range: 118*

*Number of processed events: 65*

*Frequency range used to process the data: 2 - 16 Hz*

*Processed signal length: 9s. before P, 84s. after P*

*Number of reference events: 9*

**Table 23: Reference events for area 49**

Event #	IMS orid	IMS arid	IMS wfid	Threshold	Group
45	300707	1002337	1327622	0.80	A
46	300944	1003344	1348208	0.89	B
29	28372	831799	951563	0.88	C
27	28712	830227	950378	0.88	D
3	3631	552649	647620	0.86	E
18	18167	741218	613183	0.83	F
34	32174	862924	1022270	0.83	G
10	6146	575954	686263	0.81	H
58	326329	1237126	1997553	0.92	I

*Reported mine locations:*

**Table 24: Mine location for area 49**

Label	Latitude	Longitude	Origin
NYG	60.39	5.34	-
N6	61.93	5.45	Norw

*Number of events found in the Helsinki bulletin: None*

Events with the most reliable classification:

Table 25: Sorted events for area 49

Event #	IMS orid	IMS origin time		IMS lat	IMS lon	IMS ml	Group
45	300707	10/24/91	10:46:04.7	60.1515	5.1360	2.32	A
52	315350	1/31/92	07:51:00.8	60.2130	5.0142	1.71	A
42	300386	10/17/91	15:10:32.0	60.4794	5.2585	1.70	B
46	300944	10/30/91	16:00:17.1	60.2789	5.2426	1.66	B
47	300989	10/31/91	16:04:03.6	60.5342	5.2724	1.42	B
23	24550	5/30/91	06:44:44.5	60.1704	5.4371	1.41	C
29	28372	7/4/91	06:16:59.8	60.2589	5.5065	1.35	C
37	34532	8/15/91	06:16:29.9	60.5990	5.3826	1.38	C
27	28712	7/2/91	13:19:47.1	60.6093	5.1922	1.56	D
39	40069	9/17/91	11:59:25.8	60.4941	5.8726	1.33	D
3	3631	12/13/90	11:09:25.8	60.5859	5.8890	1.48	E
43	300279	10/18/91	11:11:45.9	60.5934	5.9078	1.50	E
13	8892	1/25/91	11:25:08.6	60.3465	5.3310	1.32	F
14	15238	3/18/91	11:27:36.3	60.5287	5.8266	1.37	F
17	18187	4/15/91	06:49:03.3	60.4220	5.3083	1.50	F
18	18167	4/18/91	08:32:24.3	60.4938	5.3891	1.51	F
19	19364	4/26/91	06:55:49.7	60.4041	5.4070	1.55	F
21	23910	5/24/91	07:33:26.2	60.5902	5.8406	1.33	F
34	32174	7/26/91	13:02:57.7	60.2731	4.7349	1.32	G
54	321596	3/3/92	18:17:05.1	60.3429	5.2801	1.49	G
7	9529	12/24/90	06:47:33.6	61.4041	7.7012	1.43	H
8	6037	1/5/91	19:00:30.6	61.3750	7.5478	1.30	H
9	6091	1/6/91	06:29:14.4	61.2178	7.4486	2.24	H
10	6146	1/6/91	13:38:11.0	61.4131	7.5681	1.95	H
11	6173	1/6/91	22:14:43.3	61.3342	7.6043	1.59	H
35	32251	7/27/91	14:03:16.3	61.2058	7.5104	1.35	H
58	326329	4/28/92	17:12:58.2	61.1056	7.6509	1.67	I
61	327535	5/11/92	18:12:01.4	61.1541	7.5860	1.58	I

*Remarks:*

- Many of these events could not be sorted because they were unique.
- Events from groups A through G have locations surrounding the NYG mine.
- Events from groups H and I are located in the East part of the map (Figure 11).

*Mine and event locations:*

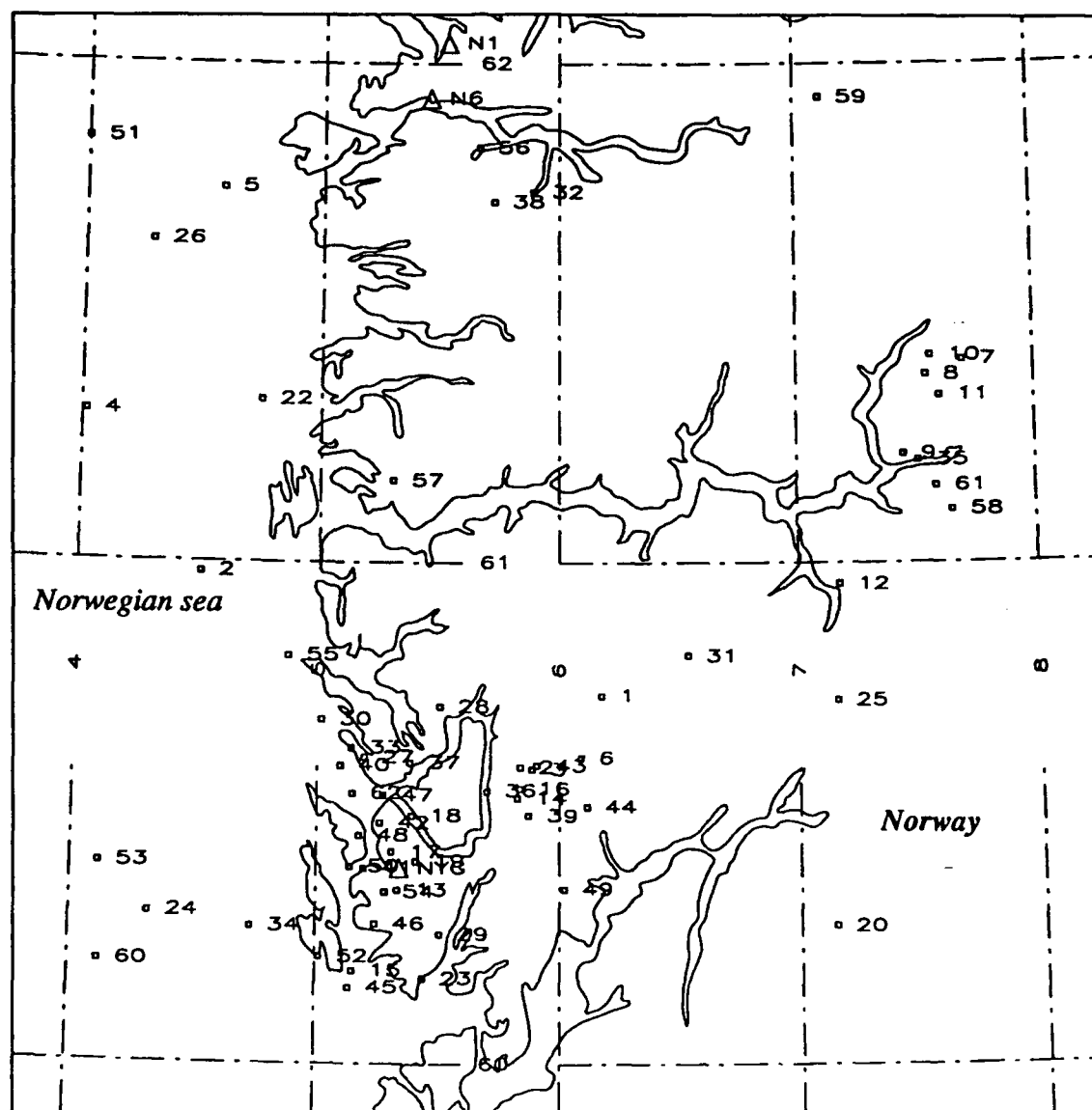


Figure 11: Mine and IMS event locations for area 49



## AREA 50

*Latitude: 58 - 60°N*

*Longitude: 4 - 8°E*

*Local magnitude range: 1.2*

*Number of events in IMS2: 211*

*Number of events within the magnitude range: 91*

*Number of processed events: 72*

*Frequency range used to process the data: 2 - 16 Hz*

*Processed signal length: 9s. before P, 79s. after P*

*Number of reference events: 8*

**Table 26: Reference events for area 50**

Event #	IMS orid	IMS arid	IMS wfid	Threshold	Group
9	19279	743789	620572	0.81	A
1	5810	526465	629104	0.83	B
28	29378	839737	967769	0.81	C
46	321701	1207027	1780431	0.83	D
52	325740	1233128	1948119	0.93	E
12	23028	787106	784305	0.83	F
14	23305	791205	798675	0.86	G
39	300612	1001966	1322012	0.86	H

*Reported mine locations:*

**Table 27: Mine locations for area 50**

Label	Latitude	Longitude	Origin
TTT	58.23	6.43	-
N15	58.30	6.40	Norw
BLA	59.31	6.95	-

*Number of events found in the Helsinki bulletin: 4*

**Table 28: Events found in the Helsinki bulletin for area 50**

Event #	IMS orid	IMS origin time		IMS ml	HEL location		HEL label	Group
40	300858	10/28/91	13:14:33.7	2.75	59.94	5.92	EARTH.	-
62	336035	8/6/92	07:32:41.3	3.15	59.89	6.15	EARTH.	-
65	337933	8/28/92	18:37:52.4	2.63	59.82	6.70	P.E.	-
53	325774	4/14/92	13:10:07.3	3.38	59.52	5.91	EARTH.	E

*Events with the most reliable classification:*

**Table 29: Sorted events for area 50**

Event #	IMS orid	IMS origin time		IMS lat	IMS lon	IMS ml	Group
4	3272	11/22/90	14:15:12.4	58.0550	6.6666	1.80	A
9	19279	4/19/91	13:14:21.0	58.2182	6.6725	1.56	A
10	19480	4/26/91	13:15:07.3	58.2166	6.8521	1.42	A
11	22647	5/14/91	13:13:06.3	58.2967	6.5724	1.55	A
22	27869	6/27/91	13:14:43.4	58.1097	6.7534	1.55	A
1	5810	11/15/90	15:09:40.3	58.8092	6.4591	1.56	B
8	9397	1/29/91	14:34:25.1	58.7170	6.4150	1.58	B
26	28961	7/4/91	16:34:53.1	59.1513	6.3919	1.42	B
35	37561	9/5/91	18:56:13.4	58.8931	6.5559	1.21	B
18	24514	5/27/91	17:18:21.9	58.6667	6.4038	1.45	C
28	29378	7/10/91	14:10:01.0	59.0038	6.1310	1.49	C
29	29377	7/10/91	14:10:10.9	58.5148	7.1255	1.39	C
58	330690	6/16/92	03:44:29.1	59.5419	5.7205	2.04	C
46	321701	3/6/92	14:18:10.7	58.3074	6.5518	1.54	D
47	325682	3/26/92	14:37:17.5	58.2612	6.6775	1.54	D
50	323688	4/3/92	13:13:20.1	58.2073	6.8003	1.64	D
66	337975	9/1/92	13:13:46.5	58.4587	6.2956	1.54	D
52	325740	4/14/92	12:46:12.0	59.4967	6.0187	2.60	E
53	325774	4/14/92	13:10:07.3	59.4524	5.8739	3.38	E
54	325775	4/14/92	13:23:01.7	59.5417	6.1037	1.41	E

**Table 29: Sorted events for area 50**

Event #	IMS orid	IMS origin time		IMS lat	IMS lon	IMS ml	Group
12	23028	5/17/91	05:32:45.0	59.9871	6.9344	1.51	F
36	39525	9/13/91	22:32:09.7	59.7945	6.9761	1.29	F
14	23305	5/22/91	14:14:09.1	59.6391	6.6143	1.21	G
19	24341	5/29/91	15:07:05.0	59.6045	6.3414	1.79	G
21	27303	6/26/91	16:11:12.9	59.7000	6.5212	1.34	G
39	300612	10/22/91	11:08:37.4	58.9134	6.1506	1.57	H
41	300674	10/30/91	08:34:24.5	59.1868	6.7418	1.31	H

**Remarks:**

- The majority of these events could not be sorted because they were unique.
- One event identified in the Helsinki bulletin has being an earthquake belongs to group E. This group consists of three events that occurred on the same day (4/14/92) within a very short period of time.

*Mine and event locations:*

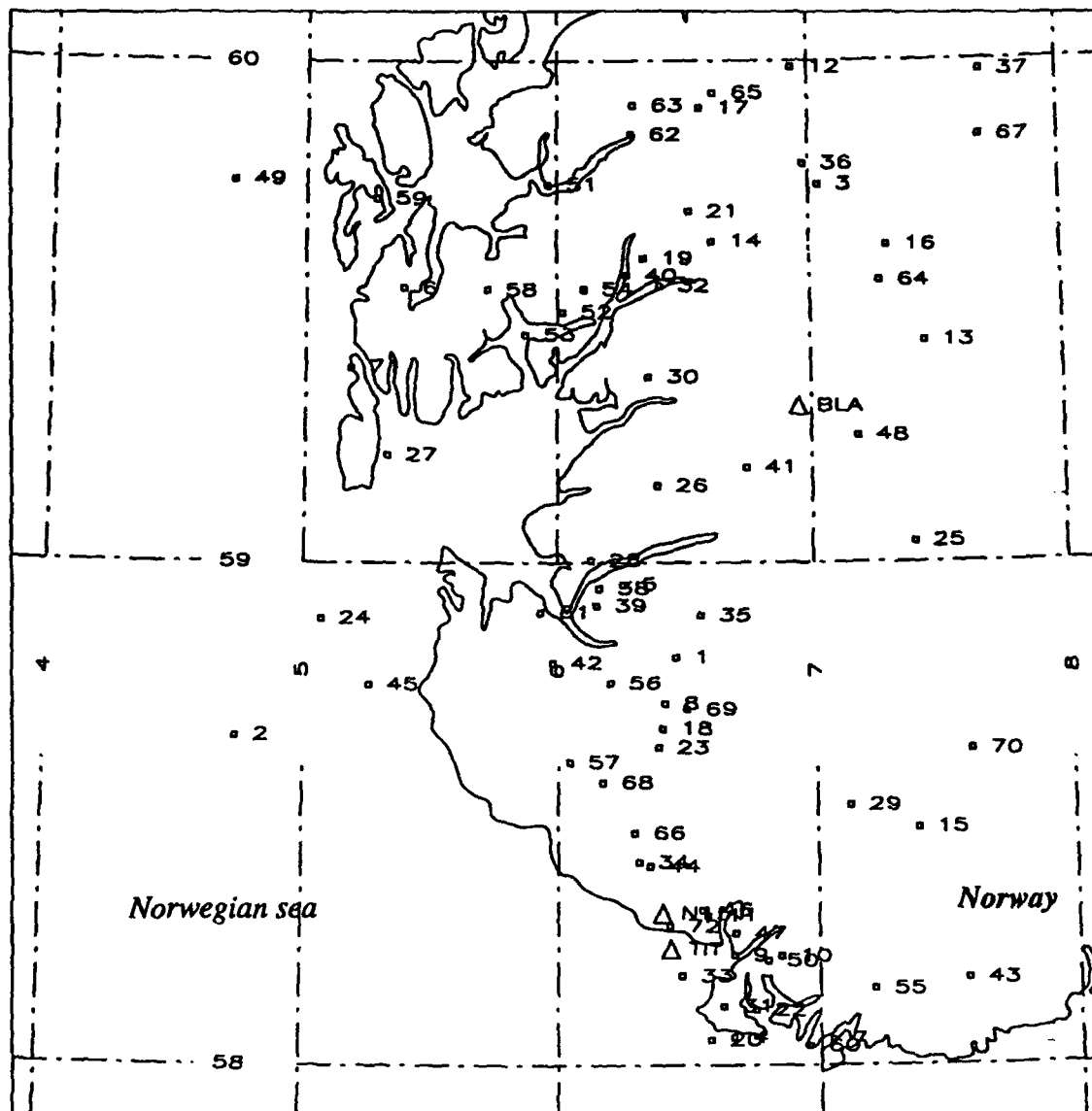


Figure 12: Mine and IMS event locations for area 50.

## AREA 51

*Latitude: 58 - 60°N*

*Longitude: 8 - 12°E*

*Local magnitude range: 1.3*

*Number of events in IMS2: 2951*

*Number of events within the magnitude range: 117*

*Number of processed events: 91*

*Frequency range used to process the data: 2 - 16 Hz*

*Processed signal length: 4s. before P, 39s. after P*

*Number of reference events: 13*

**Table 30: Reference events for area 51**

Event #	IMS orid	IMS arid	IMS wfid	Threshold	Group
67	327247	1270477	2027514	0.86	A
8	6248	576825	687814	-	B
17	13753	702380	470500	-	C
32	25792	809643	901674	0.87	D
20	16009	724976	551779	0.91	E
79	330091	1289383	2151604	0.69	F
11	7910	596036	427058	0.90	G
38	31435	857830	1005365	0.86	H
53	302078	1008790	1471111	-	I
54	302108	1009345	1498471	-	J
65	324823	1233497	1952649	0.83	K
45	300255	1001025	1306517	-	L
46	300570	1002426	1327973	0.81	M

*Reported mine locations:*

**Table 31: Mine locations for area 51**

Label	Latitude	Longitude	Origin
JOG1	59.65	9.68	JOG
JOG2	59.66	9.65	JOG
JOG3	59.66	9.69	JOG

**Table 31: Mine locations for area 51**

Label	Latitude	Longitude	Origin
JOG4	59.67	9.68	JOG
JOG5	59.68	9.68	JOG
JOG6	59.69	9.54	JOG
N16	59.75	10.77	JOG
JOG7	59.76	9.81	JOG
JOG8	59.77	9.52	JOG
JOG9	59.79	9.50	JOG
N14	59.90	10.50	JOG

*Number of events found in the Helsinki bulletin: 1*

**Table 32: Events found in the Helsinki bulletin for area 51**

Event #	IMS orid	IMS origin time		IMS ml	HEL location		HEL label	Group
58	319339	2/19/92	06:39:32.9	3.26	59.31	11.04	EART.	-

*Events with the most reliable classification:*

**Table 33: Sorted events for area 51**

Event #	IMS orid	IMS origin time		IMS lat	IMS lon	IMS ml	Group
25	19013	4/18/91	13:51:03.9	58.9260	9.7221	1.31	A
40	33825	8/5/91	13:10:18.8	59.0028	10.0863	1.55	A
50	301435	11/7/91	13:19:28.3	58.9366	9.7306	1.35	A
59	319412	2/21/92	11:42:00.4	58.9388	9.9167	1.49	A
67	327247	5/7/92	13:45:49.7	58.9934	9.7389	1.38	A
85	336488	8/20/92	13:45:20.3	58.9472	9.8357	1.31	A
86	337678	9/2/92	13:44:30.2	59.0275	9.8510	1.30	A
8	6248	1/7/91	14:02:02.7	58.8679	9.8202	1.33	B
23	18266	4/15/91	13:04:23.6	58.8153	9.9493	1.38	B
17	13753	3/11/91	15:03:15.8	58.8596	10.3410	1.32	C
41	34939	8/14/91	12:22:14.1	58.9038	10.3491	1.35	C
32	25792	6/10/91	12:14:07.0	59.1971	10.0937	1.38	D

Table 33: Sorted events for area 51

Event #	IMS orid	IMS origin time		IMS lat	IMS lon	IMS ml	Group
51	301085	11/8/91	14:05:55.2	59.1506	10.1973	1.49	D
63	322540	3/26/92	13:29:14.1	59.1888	10.3303	1.45	D
20	16009	4/2/91	13:36:47.9	59.1769	10.3070	1.37	E
24	17823	4/16/91	13:30:14.2	59.1449	10.0849	1.36	E
30	22405	5/15/91	13:20:10.7	59.1576	10.0653	1.58	E
36	28266	7/3/91	13:44:02.0	59.1971	10.1693	1.37	E
27	19846	4/25/91	12:42:03.1	58.0422	11.6992	1.40	F
28	19205	4/25/91	12:46:44.4	58.1012	11.5961	1.35	F
79	330091	6/10/92	08:14:02.5	58.1837	11.3522	1.64	F
80	330095	6/10/92	08:42:47.1	58.1982	11.3444	1.53	F
89	341050	10/5/92	10:56:57.8	59.6430	10.8735	1.30	F
11	7910	1/24/91	14:08:24.5	59.8635	10.9134	1.48	G
26	19835	4/23/91	07:51:03.4	59.4207	10.8337	1.30	G
34	27283	6/26/91	12:59:16.9	59.6396	10.9148	1.30	G
39	32265	7/30/91	07:53:24.2	59.4696	10.8745	1.53	G
38	31435	7/23/91	12:24:33.3	59.6047	10.0305	1.31	H
84	330326	6/12/92	08:11:11.6	59.5250	10.3874	1.30	H
53	302078	11/29/91	12:57:29.4	59.3138	10.1831	1.34	I
60	319265	3/3/92	15:45:52.8	59.2574	10.4462	1.46	I
54	302108	12/4/91	11:57:03.9	59.7048	8.8727	1.41	J
64	325146	4/1/92	16:28:09.5	59.8269	8.8559	1.52	J
65	324823	4/15/92	13:26:15.9	59.4284	11.6903	1.36	K
82	330258	6/11/92	17:17:36.9	59.4936	11.6659	1.44	K
88	339866	9/24/92	09:09:50.4	59.4598	11.6698	1.39	K
45	300255	10/17/91	13:36:30.9	59.3053	10.8961	1.32	L
66	327129	5/6/92	12:17:56.4	59.2731	10.8684	1.41	L
5	10215	11/26/90	14:26:09.0	58.6072	9.5349	1.35	M
46	300570	10/24/91	13:36:22.8	58.0335	8.8670	1.60	M
57	313175	1/10/92	13:02:35.2	58.0410	8.7790	1.53	M
78	330522	5/29/92	09:54:36.1	58.2122	9.0034	1.54	M

***Remarks:***

- Several clusters of events can be seen on the map (Figure 13),but none of them are located close to the reported mines.
- Most of the events are located either on the coast or off-shore.

*Mine and event locations:*

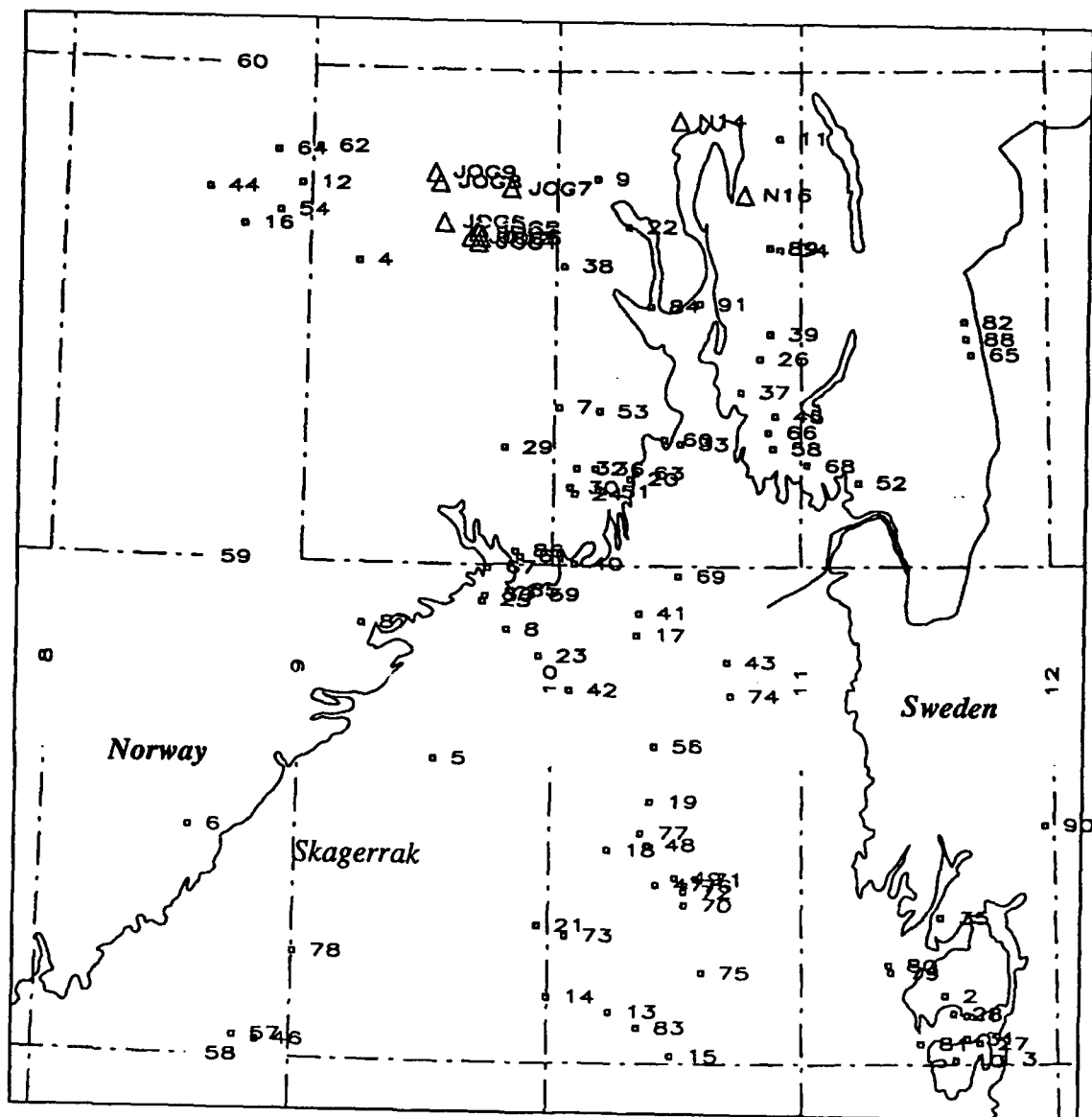


Figure 13: Mine and IMS event locations for area 51.



## AREA 52

*Latitude: 58 - 60°N*

*Longitude: 12 - 16°E*

*Local magnitude range: 1.0*

*Number of events in IMS2: 334*

*Number of events within the magnitude range: 101*

*Number of processed events: 78*

*Frequency range used to process the data: 2 - 16 Hz*

*Processed signal length: 6s. before P, 56s. after P*

*Number of reference events: 8*

**Table 34: Reference events for area 52**

Event #	IMS orid	IMS arid	IMS wfid	Threshold	Group
13	24861	799689	867597	0.83	A
47	328215	1277382	2063889	0.80	B
26	38270	926604	1206053	0.83	C
40	322856	1226347	1842861	0.83	D
53	332998	1320290	2200141	0.83	E
65	338519	1430127	2661360	0.9	F
71	341818	1481923	2777829	0.98	G
17	28176	824733	939764	-	H

*Reported mine locations:*

**Table 35: Mine locations for area 52**

Label	Latitude	Longitude	Origin
N205	58.80	15.10	Norw
N206	59.30	15.40	Norw
N209	59.70	14.10	Norw

*Number of events found in the Helsinki bulletin: None*

*Events with the most reliable classification:*

**Table 36: Sorted events for area 52**

Event #	IMS orid	IMS origin time		IMS lat	IMS lon	IMS ml	Group
10	14202	3/12/91	13:53:16.0	58.6379	12.3285	1.13	A
13	24861	5/31/91	12:01:46.6	58.6829	12.3158	1.25	A
22	32778	7/31/91	09:39:02.7	58.7156	12.4115	1.06	A
47	328215	5/18/92	14:41:14.0	58.1590	12.0917	1.45	B
57	335088	8/4/92	14:19:50.8	58.1456	12.0189	1.25	B
67	339450	9/21/92	13:35:02.9	58.0294	12.1153	1.49	B
7	13218	3/6/91	12:35:35.6	58.7789	12.5328	1.27	C
21	32103	7/29/91	12:13:18.1	58.9303	12.4282	1.27	C
23	33538	8/8/91	05:03:38.0	58.8371	12.4835	1.10	C
25	38145	9/4/91	17:29:18.0	58.9544	12.4741	1.49	C
26	38270	9/5/91	18:16:44.1	58.7730	12.4014	1.43	C
30	40950	9/26/91	07:47:17.8	58.9146	12.2083	1.10	C
34	302787	12/6/91	11:40:21.8	58.7899	12.3920	1.42	C
38	324264	3/19/92	14:53:18.8	58.7905	12.3839	1.35	C
45	327128	5/6/92	12:08:45.4	58.7946	12.0103	1.23	C
48	328325	5/19/92	14:20:25.5	58.6247	12.6884	1.11	C
49	328948	5/25/92	17:36:04.6	58.8731	12.3135	1.18	C
54	332051	6/30/92	18:22:41.8	58.8569	12.5348	1.11	C
74	342796	11/3/92	15:16:54.5	58.8499	12.4011	1.19	C
75	343811	11/17/92	14:19:50.2	58.8281	12.3672	1.33	C
15	26049	6/10/91	11:28:02.4	58.7655	12.1139	1.00	D
27	39293	9/10/91	12:10:56.1	58.8230	12.3024	1.02	D
32	300897	10/29/91	14:26:08.3	58.7269	12.1535	1.23	D
40	322856	3/23/92	16:27:13.5	58.7376	12.4634	1.54	D
44	326933	5/4/92	13:51:42.1	58.6498	12.4711	1.38	D
52	330359	6/12/92	11:57:05.6	58.9199	12.4318	1.18	D
60	335775	8/13/92	17:26:26.0	58.8233	12.2892	1.57	D
6	11208	1/18/91	12:53:09.8	58.8309	12.5740	1.31	E

Table 36: Sorted events for area 52

Event #	IMS orid	IMS origin time		IMS lat	IMS lon	IMS ml	Group
53	332998	6/24/92	17:21:03.9	58.8782	12.1242	1.07	E
55	334943	7/15/92	16:12:36.6	58.9836	12.1245	1.10	E
20	32084	7/26/91	05:43:15.8	58.8009	12.2301	1.08	F
63	337867	9/4/92	11:46:50.1	58.8951	12.4444	1.17	F
65	338519	9/10/92	19:33:57.2	58.8442	12.2616	1.16	F
56	333891	7/20/92	17:48:17.4	59.2977	12.1080	1.15	G
71	341818	10/22/92	06:25:44.5	59.2187	12.2287	1.73	G
73	342604	11/2/92	06:26:47.2	59.2752	12.4912	1.65	G
17	28176	6/28/91	10:32:55.2	58.1032	13.8678	1.26	H
39	322848	3/23/92	12:13:37.7	58.2852	13.8933	1.12	H

*Remarks:*

- The events located South-West of the Vanörn Lake have too low signal-to-noise ratios to confirm the results of the cluster analysis that grouped them. Only two events (group H) could be sorted.
- Events from group C, D, E and F have tight locations on the west side of the Vanörn Lake.

*Mine and event locations:*

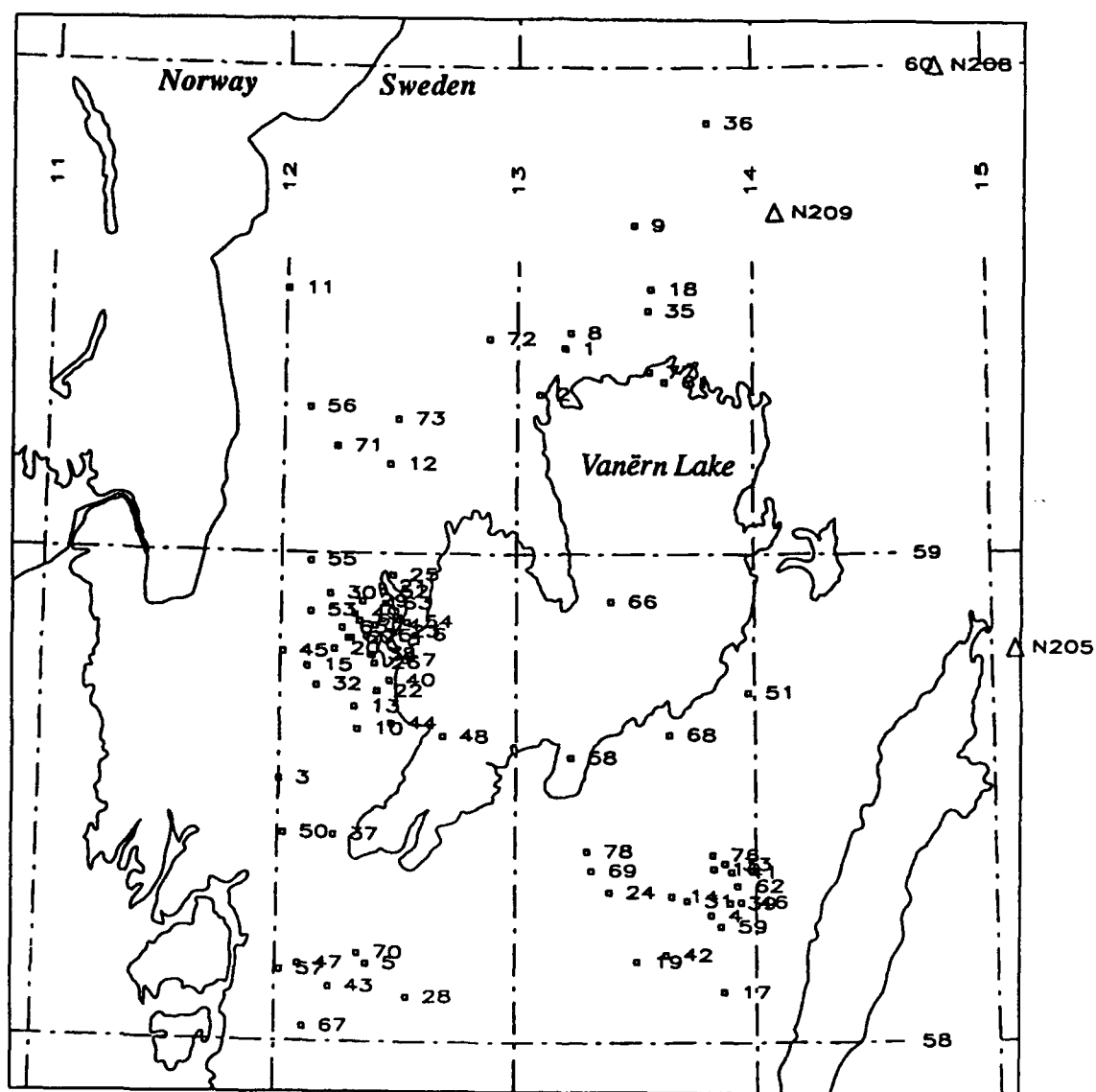


Figure 14: Mine and IMS event locations for area 52.

## AREA 53

*Latitude: 58 - 60°N*

*Longitude: 16 - 20°E*

*Local magnitude range: 1.2*

*Number of events in IMS2: 169*

*Number of events within the magnitude range: 128*

*Number of processed events: 98*

*Frequency range used to process the data: 3 - 16 Hz*

*Processed signal length: 12s. before P, 112s. after P*

*Number of reference events: 7*

**Table 37: Reference events for area 53**

Event #	IMS orid	IMS arid	IMS wfid	Threshold	Group
40	366134	1009382	1498627	0.78	A
21	18915	741334	613495	0.83	B
73	330238	1289884	2157106	-	C
94	344364	1503954	2832363	-	D
76	336034	1380051	2439166	-	E
45	302578	1010897	1515834	0.89	F
62	324579	1232679	1943397	0.88	G

*Reported mine locations: None*

*Number of events found in the Helsinki bulletin: 21*

**Table 38: Events found in the Helsinki bulletin for area 53**

Event #	IMS orid	IMS origin time		IMS ml	HEL locations		HEL label	Group
5	7937	11/23/90	09:34:51.3	2.59	58.93	18.36	-	-
8	8455	11/27/90	10:42:35.7	2.26	58.80	17.44	-	-
10	8460	11/27/90	10:59:55.3	2.44	58.82	17.65	-	-
12	314140	12/12/90	15:27:27.0	3.04	59.83	16.79	P.E.	-
13	13226	3/6/91	13:22:25.1	2.23	58.22	17.81	-	-
17	17597	4/11/91	10:49:27.9	2.81	58.30	17.79	-	-
24	20066	4/27/91	07:11:03.5	2.44	58.95	17.83	-	-
25	20067	4/27/91	07:39:16.8	2.42	58.79	18.51	-	-

**Table 38: Events found in the Helsinki bulletin for area 53**

Event #	IMS orid	IMS origin time		IMS ml	HEL locations		HEL label	Group
26	21864	5/3/91	07:44:42.9	2.37	58.57	18.55	-	-
29	21867	5/3/91	08:39:25.7	2.53	58.52	18.79	-	-
31	22774	5/15/91	08:24:25.4	2.38	58.31	17.86	-	-
36	39332	9/10/91	15:34:47.6	2.50	58.46	18.13	-	-
53	319297	2/18/92	12:02:04.8	2.19	58.98	18.34	-	-
54	320973	3/18/92	09:04:15.9	2.61	58.65	18.23	-	-
55	324871	3/26/92	11:26:27.7	2.44	58.37	18.11	-	-
56	324873	3/26/92	11:41:15.0	2.33	58.66	17.86	-	-
61	324575	4/13/92	08:27:44.4	2.20	58.99	18.48	-	-
66	328214	5/18/92	14:12:21.0	2.50	58.42	18.48	-	-
67	328236	5/18/92	19:21:18.2	2.68	58.55	18.02	-	-
71	330610	6/10/92	08:22:07.4	2.58	59.02	18.05	-	-
62	324579	4/13/92	08:45:14.3	2.79	59.04	18.55	-	G

*Events with the most reliable classification:*

**Table 39: Sorted events for area 53**

Event #	IMS orid	IMS origin time		IMS lat	IMS lon	IMS ml	Group
19	366132	4/16/91	09:47:50.7	59.7229	18.7840	1.48	A
20	366133	4/16/91	13:33:55.8	59.0776	18.1447	1.86	A
40	366134	12/4/91	13:41:49.5	59.2385	18.1164	1.88	A
43	366135	12/5/91	09:49:35.1	59.2141	18.1048	1.93	A
63	366137	5/5/92	14:05:14.5	59.0500	18.1675	1.62	A
64	366138	5/6/92	08:01:11.3	59.1166	18.1437	1.63	A
65	366139	5/18/92	13:37:08.3	58.6058	18.8748	1.68	A
75	366147	8/4/92	15:18:23.5	59.0567	18.1374	1.64	A
77	366140	8/6/92	09:40:38.2	58.6289	18.6769	1.52	A
78	366141	8/18/92	16:09:01.4	59.4235	18.0653	1.62	A
79	366142	8/20/92	10:40:30.9	59.1910	18.2219	1.53	A
80 <sup>a</sup>	366143	8/25/92	10:07:10.1	58.8805	18.3989	1.93	A

Table 39: Sorted events for area 53

Event #	IMS orid	IMS origin time		IMS lat	IMS lon	IMS ml	Group
84	366144	8/25/92	11:33:06.5	59.0465	18.1836	1.61	A
21	18915	4/18/91	10:50:26.6	59.1549	18.2128	1.81	B
69	328496	5/21/92	09:35:32.1	58.5796	16.5494	1.33	B
90	339882	9/24/92	11:07:27.2	58.3267	18.5234	1.57	B
73	330238	6/11/92	13:44:14.1	58.2613	16.2042	1.64	C
96	344881	11/27/92	11:42:02.3	58.5463	16.2929	1.49	C
94	344364	11/17/92	17:20:54.2	59.0187	18.1528	1.72	D
95	343724	11/18/92	16:12:16.3	59.0553	18.1376	1.69	D
76	336034	8/5/92	12:27:25.9	59.5233	18.1432	1.38	E
85	337742	8/25/92	12:47:03.2	59.0458	18.1929	1.49	E
41	302306	12/4/91	14:02:41.4	59.5115	18.0304	1.69	F
42	302444	12/9/91	12:55:29.1	59.7364	18.1183	1.56	F
44	302785	12/6/91	11:34:21.7	59.3975	18.0929	1.64	F
45	302578	12/11/91	13:01:23.8	59.7783	17.8460	1.70	F
14	17575	4/11/91	10:02:21.7	58.9920	18.7157	2.50	G
18	17578	4/11/91	10:07:14.7	58.9610	18.6768	2.31	G
62	324579	4/13/92	08:45:14.3	59.1134	18.6381	2.79	G

a. Mixed event.

**Remarks:**

- Events from group A were carefully re-analyzed and the analyst found that most of them were originally poorly located (Ryall, 1993). Using only ARCESS and FINESA arrival information (azimuth and time), these event locations got tighter (except for event 19 which was recorded at NORESS only). Based on these new locations, the comparison with the azimuths determined at NORESS showed that the *P<sub>n</sub>* azimuth was systematically about 18 degrees off while the *P<sub>g</sub>* azimuth was consistent with these new locations. Surprisingly, one event, larger than the events from group A, which was located in the same area, did not show this particular feature. Its *P<sub>n</sub>* azimuth at NORESS was consistent with the other phases.

*Mine and event locations:*

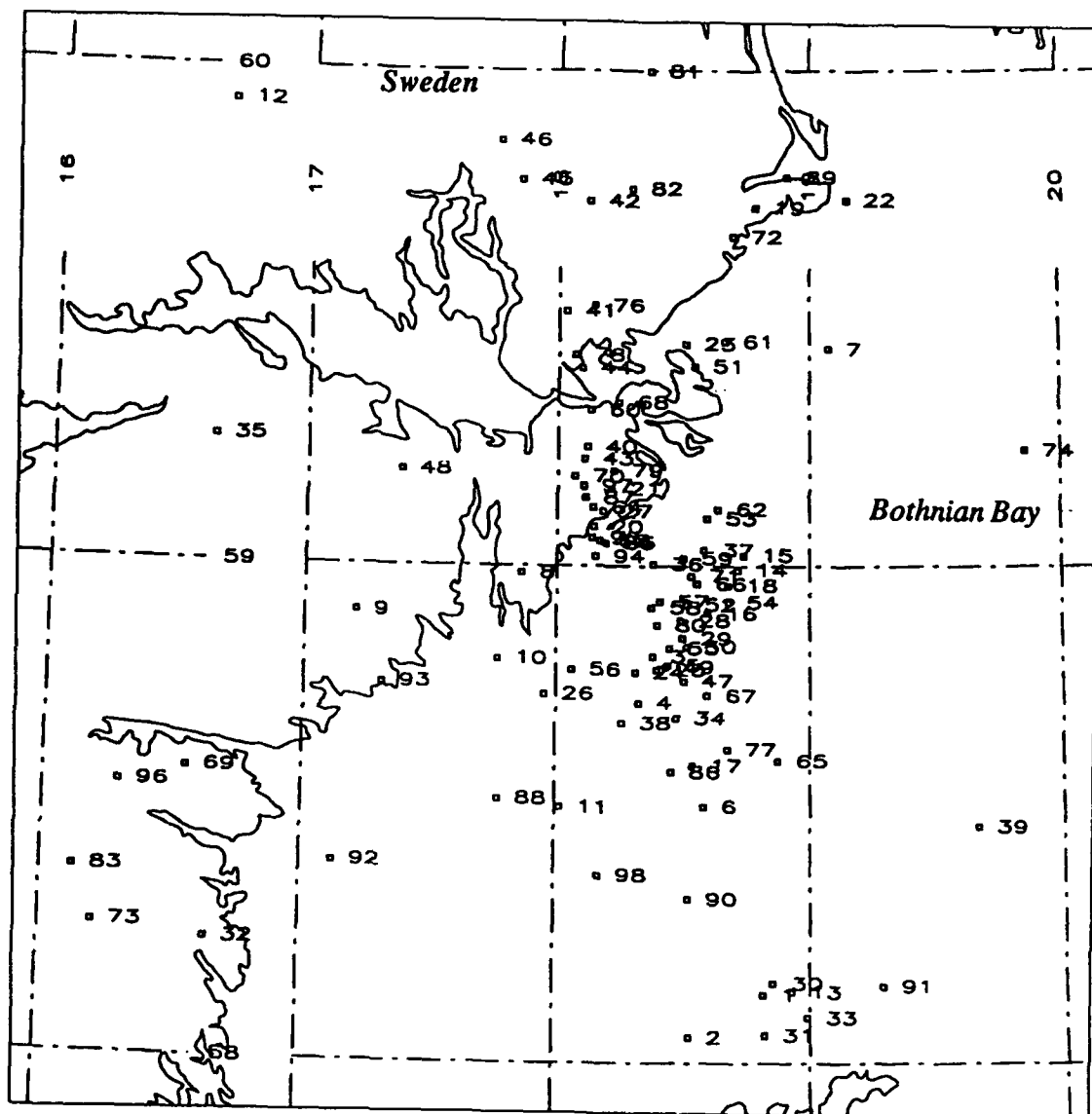


Figure 15: IMS event locations for area 53.

## AREA 62

*Latitude: 56 - 58°N*

*Longitude: 18 - 24°E*

*Local magnitude range: -*

*Number of events in IMS2: 117*

*Number of events within the magnitude range: 117*

*Number of processed events: 50*

*Frequency range used to process the data: 3 - 16 Hz*

*Processed signal length: 12s. before P, 107s. after P*

*Number of reference events: 3*

**Table 40: Reference events for area 62**

Event #	IMS orid	IMS arid	IMS wfid	Threshold	Group
41	331387	1292960	2195383	0.80	A
11	13717	699456	465190	0.81	B
8	4347	558102	1362115	-	C

*Reported mine locations: None*

*Number of events found in the Helsinki bulletin: 8*

**Table 41: Events found in the Helsinki bulletin for area 62**

Event #	IMS orid	IMS origin time		IMS ml	HEL location		HEL label	Group
13	15731	3/27/91	13:13:52.1	2.76	57.83	19.10	-	-
49	339112	9/17/92	13:24:36.4	-	57.40	17.86	-	-
3	26213	11/27/90	12:52:09.0	2.56	58.15	18.06	-	A
25	39886	9/16/91	13:14:33.8	2.40	58.02	18.47	-	A
26	39889	9/16/91	13:17:23.4	2.65	58.28	18.52	-	A
40	331394	6/23/92	12:17:52.8	2.56	58.50	18.68	-	A
41	331387	6/23/92	12:36:11.2	2.60	58.40	18.69	-	A
42	331388	6/23/92	12:40:29.5	2.51	58.23	19.38	-	A

*Events with the most reliable classification:*

**Table 42: Sorted events for area 62**

Event #	IMS orid	IMS origin time		IMS lat	IMS lon	IMS ml	Group
3	26213	11/27/90	12:52:09.0	57.5257	18.5924	2.56	A
25	39886	9/16/91	13:14:33.8	57.7868	18.9671	2.40	A
26	39889	9/16/91	13:17:23.4	57.9022	19.0654	2.65	A
40	331394	6/23/92	12:17:52.8	57.8428	19.5130	2.56	A
41	331387	6/23/92	12:36:11.2	57.5209	19.2025	2.60	A
42	331388	6/23/92	12:40:29.5	57.7262	18.9908	2.51	A
11	13717	3/8/91	14:38:17.3	56.9736	23.5002	1.93	B
16	16777	4/2/91	11:37:44.5	56.8348	23.7904	2.02	B
34	320015	3/5/92	14:15:52.0	57.2368	23.2869	1.93	B
35	320969	3/16/92	13:45:21.9	56.9393	23.6839	2.04	B
44	335515	7/24/92	13:49:55.2	56.9806	23.7871	-	B
8	4347	12/19/90	11:25:25.8	56.4821	22.3512	1.99	C
9	5206	12/22/90	10:35:41.0	56.4900	22.2748	1.98	C

*Remarks:*

- More than half of the events could not be sorted because of too low signal-to-noise ratios. Most of them are located in Latvia, East of the map (Figure 16).
- Events from group A are located off-shore of the Gotland Island.
- Events from group B are located in Latvia. No mines locations are been reported for this area.

*Mine and event locations:*

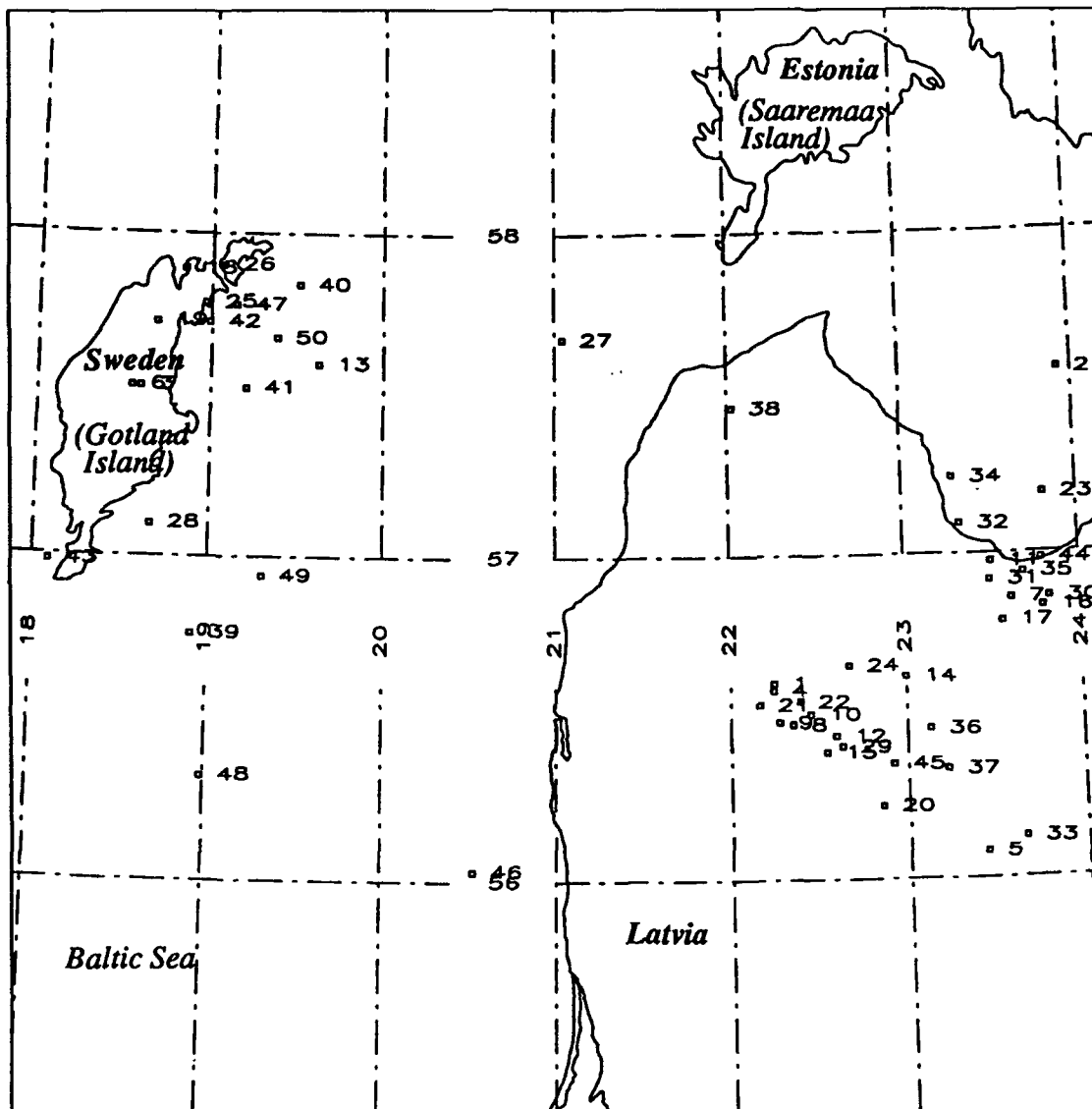


Figure 16: IMS event locations for area 62.



## AREA 63

*Latitude: 56 - 58°N*

*Longitude: 12 - 18°E*

*Local magnitude range: -*

*Number of events in IMS2: 62*

*Number of events within the magnitude range: 62*

*Number of processed events: 49*

*Frequency range used to process the data: 3 - 16 Hz*

*Processed signal length: 12s. before P, 107s. after P*

*Number of reference events: 4*

**Table 43: Reference events for area 63**

Event #	IMS orid	IMS arid	IMS wfid	Threshold	Group
40	340379	1458811	2725482	0.86	A
17	25690	804863	885111	0.82	B
7	14473	705485	486460	0.80	C
6	13630	704811	484255	0.81	D

*Reported mine locations: None*

*Number of events found in the Helsinki bulletin: None*

*Events with the most reliable classification:*

**Table 44: Sorted events for area 63**

Event #	IMS orid	IMS origin time		IMS lat	IMS lon	IMS ml	Group
40	340379	9/29/92	14:18:47.6	56.9613	17.3405	1.66	A
41	341251	10/13/92	12:10:08.7	57.5232	15.8931	1.48	A
5	14198	3/12/91	15:16:07.1	57.4939	14.8966	1.66	B
15	23383	5/23/91	12:13:47.6	57.4323	14.4869	1.85	B
17	25690	6/5/91	14:48:27.0	57.4697	14.5920	1.73	B
23	38718	9/12/91	12:41:05.8	57.5766	15.5118	1.58	B
26	301249	11/12/91	15:19:59.9	57.3412	14.0818	1.65	B
35	328094	5/15/92	10:29:47.4	57.6010	14.7966	1.65	B
7	14473	3/14/91	12:59:02.2	57.5006	13.0834	1.21	C
38	338268	9/9/92	10:45:10.7	57.4306	12.9340	1.24	C

**Table 44: Sorted events for area 63**

Event #	IMS orid	IMS origin time		IMS lat	IMS lon	IMS ml	Group
47	343346	11/13/92	12:55:35.3	57.4767	12.8758	-999.00	C
6	13630	3/13/91	19:07:44.4	56.9882	12.3802	1.17	D
9	19709	4/22/91	13:35:54.8	57.8735	15.1142	1.34	D

**Remarks:**

- The event locations show two clusters in the North-western part of the map (Figure 17) whose events could not be sorted because of too low signal-to-noise ratios.
- The two events from group A are 108 km apart; one of them being located off-shore.

*Mine and event locations:*

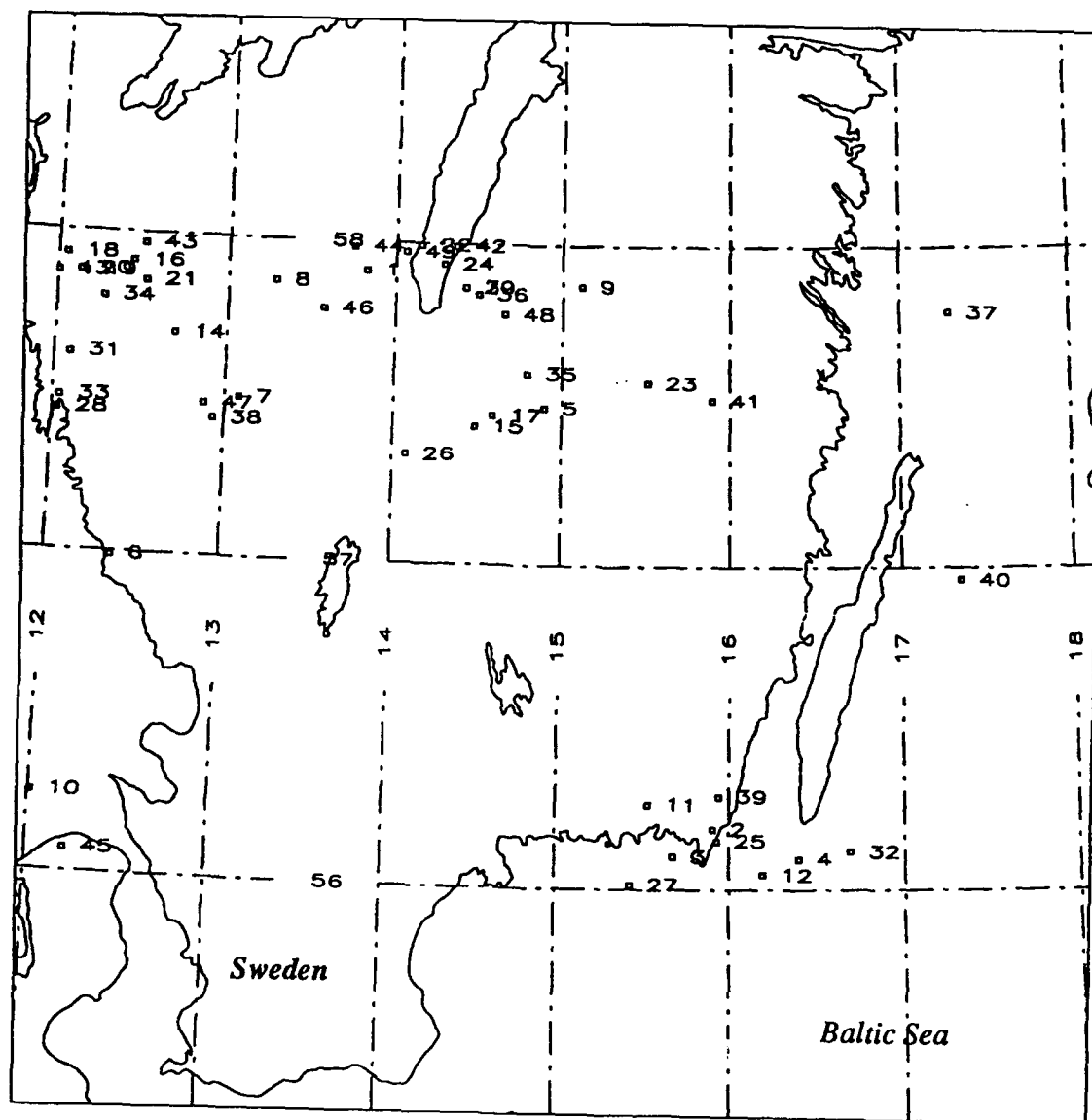


Figure 17: IMS event locations for area 63.



## AREA 64

*Latitude: 56 - 58°N*

*Longitude: 6 - 12°E*

*Local magnitude range: -*

*Number of events in IMS2: 142*

*Number of events within the magnitude range: 142*

*Number of processed events: 115*

*Frequency range used to process the data: 2 - 16 Hz*

*Processed signal length: 11s. before P, 96s. after P*

*Number of reference events: 11*

**Table 45: Reference events for area 64**

Event #	IMS orid	IMS arid	IMS wfid	Threshold	Group
45	27650	815271	927999	0.80	A
110	343709	1504199	2842572	0.70	B
21	15848	716194	523412	0.81	C
92	339186	1438767	2687688	0.89	D
77	330527	1285142	2091043	0.80	E
51	38630	929469	1212854	0.78	F
39	24372	795597	819387	-	G
60	301156	1005020	1397527	0.80	H
58	300990	1003549	1391941	-	I
97	340594	1459335	2734650	0.79	J
89	333015	1323633	2212996	0.79	K

*Reported mine locations: None*

*Number of events found in the Helsinki bulletin: 1*

**Table 46: Events found in the Helsinki bulletin for area 64**

Event #	IMS orid	IMS origin time		IMS ml	HEL location		HEL label	Group
73	328497	5/18/92	05:28:35.1	2.92	57.11	6.94	P.E.	E

*Events with the most reliable classification:*

**Table 47: Sorted events for area 64**

Event #	IMS orid	IMS origin time		IMS lat	IMS lon	IMS ml	Group
17	15075	3/17/91	02:59:54.3	57.6691	6.7968	1.25	A
22	16324	4/1/91	16:11:07.2	57.2006	8.1062	1.27	A
33	21600	4/30/91	18:03:08.7	56.1290	11.8911	1.80	A
34	21599	4/30/91	18:03:22.3	56.3017	11.3407	1.54	A
37	22811	5/10/91	23:55:55.7	57.6129	6.7260	1.34	A
45	27650	6/18/91	02:45:34.2	57.4508	7.3407	1.55	A
50	34704	8/8/91	21:03:41.3	57.5904	6.9570	1.06	A
52	40688	9/20/91	15:55:59.8	57.8039	6.4939	1.34	A
66	321561	3/18/92	20:53:26.3	57.1663	8.5006	1.42	A
86	331415	6/20/92	21:44:12.9	57.4552	7.2628	1.77	A
105	342787	11/2/92	04:14:25.6	57.4435	7.5165	1.36	A
111	343814	11/18/92	22:19:27.1	57.4590	7.3308	1.48	A
112	344880	11/27/92	07:46:12.2	57.4799	7.4979	2.18	A
14	3120	11/5/90	21:52:52.6	57.8452	8.1242	2.17	B
8	313962	12/7/90	14:13:43.1	57.9726	7.2067	1.51	B
20	15284	3/21/91	14:12:02.5	57.9404	6.9363	1.73	B
36	22309	5/8/91	13:14:31.9	57.9952	7.0939	1.43	B
103	342487	10/30/92	14:15:41.6	57.8644	6.3830	1.49	B
110	343709	11/18/92	14:11:38.5	57.9378	6.0765	1.47	B
21	17583	4/10/91	08:03:52.3	57.7629	11.2689	2.14	C
106	343018	11/8/92	17:29:34.5	57.7937	8.7733	-	C
107	343333	11/13/92	10:56:48.1	57.9728	8.5523	-	C
70	325803	4/20/92	06:35:35.4	56.9995	7.2822	2.44	D
92	339186	9/17/92	00:16:18.1	57.1876	7.5203	2.09	D
114	347473	1/8/93	13:46:49.2	57.2859	7.8773	1.90	D
73	328497	5/18/92	05:28:35.1	57.0272	6.8502	2.92	E
75	328630	5/19/92	15:17:12.3	57.1190	6.0158	1.40	E
77	330527	5/23/92	17:12:34.8	56.9419	7.1445	1.50	E

Table 47: Sorted events for area 64

Event #	IMS orid	IMS origin time		IMS lat	IMS lon	IMS ml	Group
51	38630	9/7/91	23:30:30.3	57.4472	7.8372	1.47	F
61	301486	11/10/91	08:16:55.3	57.3606	7.8960	1.47	F
85	331412	6/20/92	17:41:32.4	57.3189	7.7531	1.52	F
39	24372	5/27/91	09:04:57.3	57.6840	11.6445	1.61	G
40	24374	5/27/91	09:13:28.7	57.6508	11.5641	1.50	G
38	23470	5/22/91	13:17:38.7	57.5896	8.1491	1.43	H
60	301156	11/8/91	14:17:32.0	57.8668	6.5238	1.27	H
109	344363	11/17/92	15:56:58.5	57.1853	8.3760	1.08	H
58	300990	10/31/91	17:20:52.1	57.8265	8.7756	1.04	I
83	330694	6/16/92	09:05:24.1	56.8789	9.6951	1.72	I
29	20057	4/26/91	16:59:18.0	57.3838	10.2827	1.97	J
90	336039	8/7/92	08:08:06.4	57.4881	10.5152	1.49	J
94	340559	9/29/92	16:52:43.8	57.4369	10.1559	1.26	J
95	340591	10/1/92	13:08:20.9	57.7191	10.6970	1.58	J
97	340594	10/1/92	14:40:53.4	57.6482	10.4000	1.28	J
43	26007	6/11/91	06:42:04.0	57.3321	10.8044	1.26	K
82	330304	6/12/92	03:16:06.6	57.2494	9.0789	1.52	K
89	333015	6/28/92	08:55:05.5	57.7793	10.4574	0.93	K

**Remarks:**

- Most of the events occurring in this area are located off-shore.
- Within a group, event locations spread over large areas.
- Events from group G, H and I are located close to the Swedish coast along with 18 other events that could not be sorted because of their too low signal-to-noise ratios.

*Mine and event locations:*

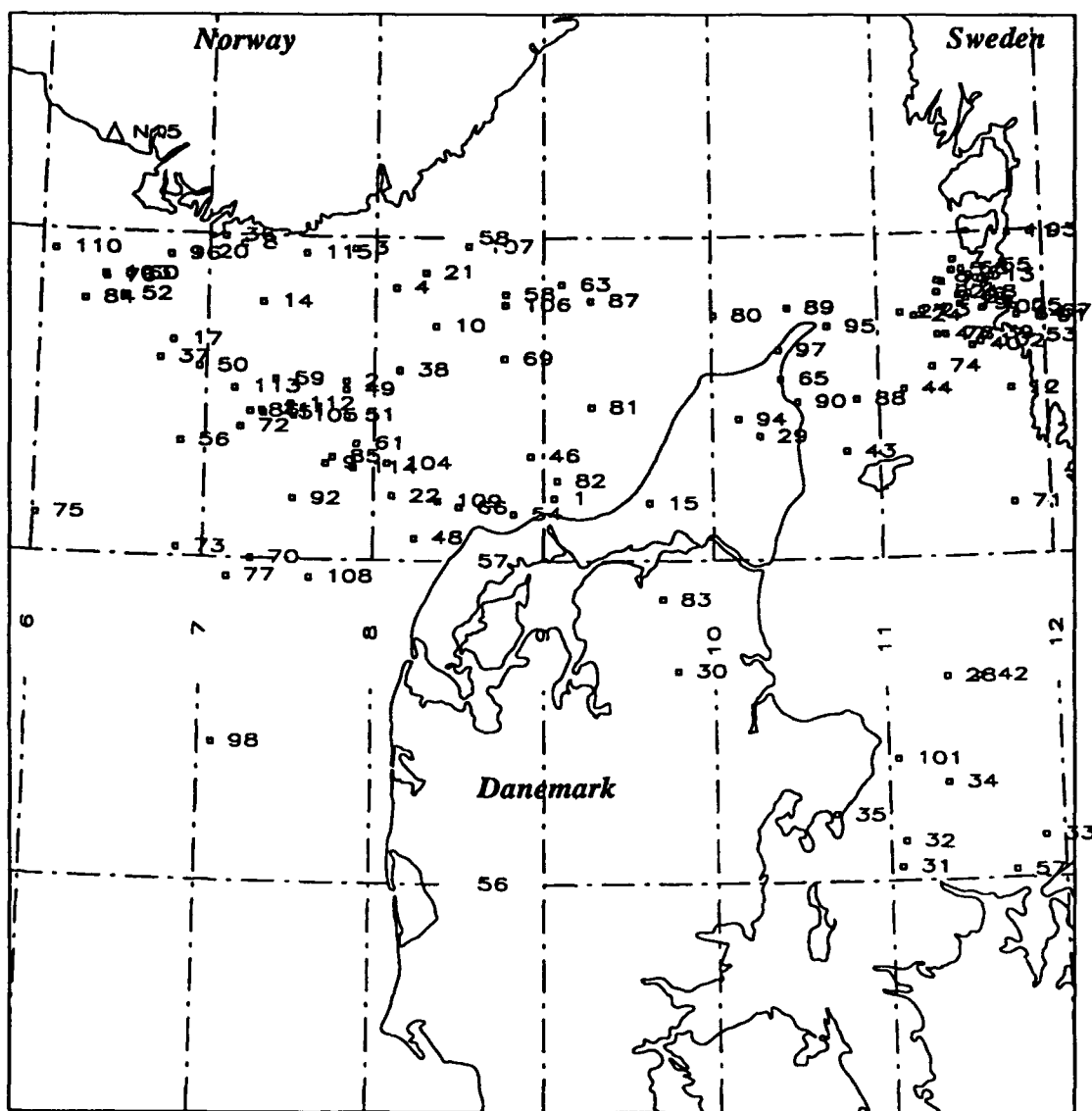


Figure 18: IMS event locations for area 64.

## APPENDIX 2



The following table gives the list of the processing parameters used to perform the waveform comparison for each area. Lat1, Lat2, Lon1, and Lon2 give the limits of each area. Lfc and Hfc give the low frequency and the high frequency corner in Hz, respectively, used in the filtering. Sbf and Saf give, in seconds, the time before the first arrival and the time after the first arrival, respectively, defining the signal length.

**Table 48: Processing parameters for NORESS data**

Area	Lat1	Lat2	Lon1	Lon2	Lfc	Hfc	Sbf	Saf
26	64	66	10	18	3.0	16.0	14	134
27	64	66	18	24	3.0	16.0	14	139
31	62	64	5	8	2.0	16.0	7	62
32	62	64	8	12	2.0	16.0	7	62
33	62	64	12	18	3.5	16.0	10	90
34	62	64	18	24	3.5	16.0	14	134
46	60	62	16	20	3.5	16.0	9	84
47	60	62	12	16	2.0	16.0	4	39
48	60	62	8	12	2.0	16.0	4	34
49	60	62	4	8	2.0	16.0	9	84
50	58	60	4	8	2.0	16.0	9	79
51	58	60	8	12	2.0	16.0	4	39
52	58	60	12	16	2.0	16.0	6	56
53	58	60	16	20	3.0	16.0	12	112
62	56	58	18	24	3.0	16.0	12	107
63	56	58	12	18	3.0	16.0	12	107
64	56	58	6	12	2.0	16.0	11	95



## APPENDIX 3



The mine locations provided in this appendix cover more than the studied area. Distance 1 defines the distance to the ARCESS array in degrees and Distance 2, in kilometers. Mines are ordered by increasing longitude.

**Table 49: SPOT mine locations**

Label	Latitude	Longitude	Distance 1	Distance 2	Azimuth
SB8	59.230	24.235	10.36	1238.710	2.49
SB1	59.242	24.329	10.35	1237.03	2.30
SB11	59.243	27.833	10.38	1241.14	355.45
SB9	59.269	27.732	10.35	1237.55	355.64
SB10	59.306	27.626	10.31	1232.64	355.83
SB7	59.325	27.272	10.28	1228.91	356.52
SB6	59.327	27.070	10.27	1227.97	356.91
SB12	59.364	28.365	10.29	1229.58	354.36
SB14	59.369	28.527	10.29	1229.98	354.04
SB13	59.370	28.428	10.28	1229.24	354.24
SB2	59.407	24.591	10.18	1216.68	1.82
SB5	59.446	26.486	10.14	1212.13	358.04
SB16	59.482	29.930	10.27	1227.52	351.25
SB15	60.019	29.742	9.72	1162.13	351.15
SC3b	60.581	29.064	9.11	1089.55	352.08
SC3a	60.599	29.073	9.10	1087.48	352.04
SC2	60.699	29.178	9.01	1076.48	351.73
SC1a	60.747	28.836	8.93	1068.01	352.44
SC1c	60.749	28.854	8.93	1067.91	352.40
SC1b	60.753	28.846	8.93	1067.37	352.41
SC0	60.816	28.711	8.86	1058.85	352.66
SC4c	60.843	28.989	8.85	1057.81	352.02
SC4b	60.849	28.979	8.84	1057.02	352.03
SC4a	60.851	28.991	8.84	1056.88	352.00
SC19	60.852	30.096	8.93	1067.13	349.55

**Table 49: SPOT mine locations**

Label	Latitude	Longitude	Distance 1	Distance 2	Azimuth
SC6	60.951	29.175	8.75	1046.55	351.50
SC7	60.961	29.312	8.75	1046.56	351.18
SC8	60.969	28.880	8.72	1041.96	352.15
SC9	60.974	29.054	8.72	1042.79	351.75
SC10	60.985	29.275	8.73	1043.39	351.24
SC5b	60.999	29.026	8.70	1039.59	351.79
SC5c	61.005	29.043	8.69	1039.02	351.74
SC5a	61.008	29.016	8.69	1038.43	351.80
SC11c	61.120	29.902	8.65	1033.47	349.67
SC11b	61.132	29.823	8.63	1031.23	349.83
SC11a	61.133	29.845	8.63	1031.34	349.78
SC12d	61.199	29.727	8.55	1022.34	349.97
SC12c	61.201	29.731	8.55	1022.15	349.96
SC12b	61.204	29.727	8.55	1021.75	349.97
SC12a	61.208	29.727	8.54	1021.28	349.96
SC13	61.270	29.804	8.49	1014.74	349.71
SC14	61.604	31.283	8.31	993.565	345.82
SC17	61.664	31.654	8.30	991.958	344.87
SC15b	61.666	31.144	8.24	984.421	346.04
SC15a	61.672	31.139	8.23	983.653	346.04
SC16	61.691	31.274	8.23	983.321	345.70
SC18b	61.946	30.606	7.90	944.600	346.85
SC18a	61.952	30.575	7.89	943.502	346.92
SD44	67.607	33.486	3.51	419.675	307.12
SD43	67.645	32.912	3.31	396.102	308.34
SD42	67.759	32.824	3.22	384.554	307.03
SD41	67.803	32.781	3.18	379.824	306.53
SD49	67.889	34.566	3.69	441.618	300.73

**Table 49: SPOT mine locations**

Label	Latitude	Longitude	Distance 1	Distance 2	Azimuth
SD40	67.893	33.029	3.20	382.702	304.46
SD50	67.895	34.615	3.71	443.158	300.55
SD47	67.916	34.385	3.62	432.924	300.75
SD48	67.926	34.486	3.65	436.243	300.40
SD46	68.006	34.697	3.68	439.762	298.89
SD45	68.019	34.349	3.56	425.319	299.39
SD39	68.040	33.229	3.18	380.626	301.68
SD38	68.082	33.219	3.16	377.616	301.06
SD37	68.112	32.986	3.07	366.807	301.20
SD35	68.120	33.400	3.20	382.288	300.01
SD36	68.133	33.162	3.11	372.289	300.40
SD34	68.251	33.267	3.09	369.437	298.24
SD33	68.268	33.403	3.13	373.830	297.65
SD32	68.700	33.125	2.86	341.371	290.61
SD31	68.791	33.146	2.83	338.543	288.84
SD30	68.792	33.133	2.83	337.969	288.84
SD29	68.872	33.025	2.76	330.521	287.43
SD28	68.930	33.096	2.77	331.448	286.18
SD18	68.932	34.938	3.41	408.182	284.60
SD27	68.943	32.965	2.72	325.576	286.08
SD26	68.997	32.871	2.68	319.927	285.07
SD25	68.999	32.910	2.69	321.488	284.99
SD23	69.012	33.641	2.94	351.583	284.07
SD24	69.013	32.939	2.70	322.265	284.67
SD22	69.034	33.506	2.89	345.307	283.75
SD21	69.060	33.484	2.87	343.658	283.26
SD17	69.064	35.008	3.41	407.414	282.40
SD16	69.070	35.008	3.41	407.260	282.30

**Table 49: SPOT mine locations**

Label	Latitude	Longitude	Distance 1	Distance 2	Azimuth
SD20	69.093	33.482	2.87	342.686	282.62
SD19	69.111	33.594	2.90	346.913	282.20
SD15	69.223	33.168	2.73	326.429	280.16
SD14	69.256	33.106	2.70	323.149	279.49
SD12	69.276	32.811	2.60	310.367	279.16
SD13	69.286	32.903	2.63	314.044	278.91
SD11	69.299	32.721	2.56	306.157	278.68
SD4	69.329	30.019	1.61	192.217	279.50
SD2	69.367	30.093	1.63	194.620	278.09
SD3	69.368	30.134	1.64	196.324	278.02
SD7	69.398	30.614	1.81	216.018	276.75
SD8	69.401	30.847	1.89	225.767	276.58
SD9	69.409	30.953	1.93	230.115	276.31
SD10	69.410	32.135	2.34	279.794	276.17
SD6	69.432	30.527	1.77	211.918	275.69
SD5	69.435	30.531	1.77	212.051	275.59
SD1	69.597	30.049	1.60	190.838	269.89

Two tables are provided for the Helsinki mine locations. The locations shown in Table 50 started to be used at the beginning of June 1991. A mapping between the new Helsinki locations and the old Helsinki locations is proposed in this table. Certain mines can have up to four different locations reported in the Helsinki bulletin; only the most frequent are listed. Locations given with one decimal were obtained by averaging seismic locations; locations with two decimals were obtained from the SPOT imagery.

**Table 50: Helsinki mine locations**

Label	Old label	Latitude	Longitude	Distance 1	Distance 2	Azimuth
HE1	HB1	59.24	24.33	10.35	1237.270	2.30
HE5A	HB9	59.24	27.83	10.39	1241.480	355.46
HE5	HB9	59.27	27.73	10.35	1237.420	355.64

Table 50: Helsinki mine locations

Label	Old label	Latitude	Longitude	Distance 1	Distance 2	Azimuth
HE6A	HB10	59.3	27.5	10.31	1232.810	356.08
HE7	HB11	59.3	28.1	10.34	1235.700	354.91
HE6	HB10	59.31	27.63	10.31	1232.180	355.82
HE4	HB6	59.33	27.27	10.28	1228.310	356.52
HE4A	HB6	59.33	27.07	10.27	1227.610	356.91
HE12A	HB12	59.36	28.37	10.29	1230.080	354.35
HE12	HB12	59.37	28.43	10.28	1229.260	354.23
HE8	HB13	59.37	28.53	10.29	1229.880	354.04
HE2	HB2	59.41	24.59	10.18	1216.320	1.82
HE9	HB5	59.45	26.49	10.14	1211.660	358.03
HE3	HB3	59.5	25.0	10.08	1204.910	1.02
HE11	HB16	59.6	30.0	10.16	1214.190	351.01
HE10	HB15	60.0	29.9	9.75	1165.860	350.85
HE10A	HB15	60.02	29.74	9.72	1161.990	351.15
HM1	HA1	60.17	23.84	9.43	1127.390	3.58
HM3	HA2	60.30	22.29	9.37	1120.340	6.96
HV11	HC3	60.6	29.2	9.11	1088.420	351.77
HV12	HC1	60.7	28.7	8.97	1072.570	352.78
HV5	HC2	60.7	29.0	8.99	1074.890	352.12
HV13	HC7	60.8	29.5	8.93	1067.350	350.92
HV1B	HC4	60.8	29.3	8.91	1065.550	351.36
HV1A	HC6	60.9	29.4	8.82	1054.590	351.04
HV1C	HC5	60.9	29.3	8.81	1053.690	351.26
HV2	HC11	61.1	30.3	8.70	1040.140	348.80
HV8	HC11	61.1	29.9	8.66	1035.800	349.70
HM2	HA3	61.33	23.03	8.30	992.660	6.04
HV4	HC14	61.4	31.6	8.55	1021.780	345.45
HV6	HC15	61.4	34.3	8.94	1068.340	339.75

Table 50: Helsinki mine locations

Label	Old label	Latitude	Longitude	Distance 1	Distance 2	Azimuth
HV3	HC12	61.5	30.4	8.32	994.286	348.03
HM5	HA4	61.6	21.7	8.12	970.875	9.51
HM26	HA5	61.64	24.26	7.95	949.899	3.17
HM4	HA6	61.9	21.5	7.84	937.384	10.37
HV7	HC13	61.9	30.6	7.95	949.899	346.94
HM27	-	61.94	29.03	7.76	928.011	350.79
HM6	HA7	62.07	27.41	7.54	901.123	354.89
HV9	HC16	62.2	34.3	8.19	978.847	337.82
HM15	HA8	62.5	30.1	7.31	873.457	347.20
HM21	HA9	62.6	23.6	7.01	837.805	5.50
HM20	HA10	62.7	23.2	6.93	828.226	6.74
HM14	HA11	62.8	22.9	6.85	818.395	7.71
HM12	HA12	62.83	29.25	6.90	825.018	348.98
HM18	HA14	63.0	26.8	6.59	787.184	356.03
HM19	HA13	63.02	29.23	6.71	802.434	348.73
HM7	HA15	63.12	27.74	6.51	777.713	353.05
HM17	HA16	63.16	27.99	6.48	774.690	352.24
HM23	HA18	63.3	29.3	6.44	770.283	348.03
HM16	HA17	63.4	27.3	6.20	741.663	354.15
HM13	HA19	63.66	26.05	5.91	705.992	358.14
HM24	HA20	63.85	25.05	5.71	683.054	1.61
HM10	HA22	64.1	27.1	5.50	656.995	354.14
HM9	HA21	64.1	24.7	5.47	653.804	2.97
HM8	HA23	64.12	28.06	5.53	661.291	350.64
HM11	HA24	64.41	25.15	5.15	615.717	1.39
HV10	HC17	64.68	30.66	5.27	630.425	339.89
HM22	HA25	65.78	24.70	3.79	452.502	4.30
HM25	HA26	65.8	28.10	3.88	463.898	346.40

**Table 50: Helsinki mine locations**

Label	Old label	Latitude	Longitude	Distance 1	Distance 2	Azimuth
HR3	HE1	67.12	20.90	2.97	354.734	33.06
HR1	HE1	67.18	20.67	2.97	354.764	34.94
HK8	HD1	67.56	30.44	2.69	321.321	319.83
HK5	HD10	67.6	34.2	3.74	446.567	305.31
HK1A	HD8/HD9	67.63	33.84	3.61	431.064	305.85
HK2	HD8/HD9	67.64	34.02	3.66	437.065	305.26
HK2A	HD8/HD9	67.64	33.88	3.61	431.848	305.62
HR2	HE2	67.65	21.00	2.51	300.478	39.05
HK1	HD8	67.67	33.74	3.55	424.547	305.59
HK7	HD3	67.7	31.4	2.84	339.396	313.18
HM28	-	67.79	24.43	1.80	214.830	12.16
HR4	HE2	67.8	20.2	2.61	311.740	45.63
HK4	HD6	68.16	33.18	3.11	371.356	299.93
HK11	HD5	68.87	33.03	2.77	330.799	287.46
HK10	HD12	69.2	34.7	3.27	391.275	280.18
HK12	HD7	69.23	33.17	2.73	326.366	280.01
HK9	HD11	69.3	34.4	3.15	376.717	278.44
HK3	HD2	69.4	30.8	1.87	223.806	276.63
HK6	HD4	69.6	32.3	2.39	285.180	271.61
HN1	HF1	69.6	29.9	1.54	184.594	269.63

**Table 51: Old Helsinki mine locations**

Label	Latitude	Longitude	Distance 1	Distance 2	Azimuth
HB9	59.2	27.6	10.417	1158.32	355.924
HB1	59.3	24.4	10.289	1144.09	2.178
HB10	59.3	27.6	10.317	1147.2	355.884
HB11	59.3	28.1	10.337	1149.43	354.910
HB6	59.3	27.2	10.303	1145.65	356.667

**Table 51: Old Helsinki mine locations**

Label	Latitude	Longitude	Distance 1	Distance 2	Azimuth
HB12	59.4	28.4	10.252	1139.98	354.273
HB13	59.4	28.5	10.257	1140.53	354.078
HB2	59.4	24.6	10.185	1132.53	1.802
HB3	59.5	25.0	10.080	1120.85	1.016
HB5	59.5	26.5	10.086	1121.52	358.003
HB16	59.6	30.0	10.157	1129.41	351.009
HB15	60.0	29.9	9.753	1084.49	350.847
HA1	60.2	23.1	9.429	1048.46	5.170
HA2	60.4	22.4	9.266	1030.34	6.797
HC3	60.6	29.2	9.105	1012.43	351.767
HC1	60.7	28.7	8.972	997.645	352.781
HC2	60.7	29.0	8.992	999.869	352.117
HC4	60.8	29.3	8.914	991.196	351.361
HC7	60.8	29.5	8.929	992.864	350.918
HC5	60.9	29.3	8.815	980.187	351.264
HC6	60.9	29.4	8.822	980.966	351.040
HC10 <sup>a</sup>	61.1	39.9	10.351	1150.98	330.883
HC11	61.1	30.2	8.692	966.51	349.020
HA3	61.4	22.8	8.246	916.917	6.647
HC14	61.4	31.6	8.548	950.498	345.450
HC15	61.4	34.3	8.937	993.753	339.749
HC12	61.5	30.4	8.318	924.923	348.028
HA4	61.6	21.7	8.122	903.129	9.511
HA5	61.6	24.2	7.988	888.229	3.306
HA6	61.9	21.5	7.842	871.994	10.375
HC13	61.9	30.6	7.946	883.559	346.944
HA7	62.1	27.4	7.508	834.855	354.895
HC16	62.2	34.3	8.188	910.468	337.819

**Table 51: Old Helsinki mine locations**

Label	Latitude	Longitude	Distance 1	Distance 2	Azimuth
HA8	62.5	30.1	7.307	812.505	347.203
HA9	62.6	23.6	7.009	779.369	5.501
HA10	62.7	23.2	6.928	770.362	6.736
HA11	62.8	22.9	6.846	761.244	7.709
HA12	62.8	29.3	6.936	771.251	348.887
HA13	62.9	28.7	6.787	754.683	350.455
HA14	63.0	26.8	6.585	732.222	356.028
HA15	63.2	27.8	6.430	714.986	352.777
HA16	63.2	28.1	6.448	716.988	351.850
HA17	63.4	27.3	6.204	689.856	354.152
HA18	63.5	29.6	6.277	697.974	346.723
HA19	63.7	26.0	5.865	652.161	358.299
HA20	63.8	25.1	5.764	640.93	1.421
HA21	64.1	24.7	5.469	608.128	2.975
HA22	64.1	27.1	5.496	611.13	354.136
HA23	64.2	28.0	5.448	605.793	350.723
HA24	64.4	25.2	5.160	573.768	1.196
HC17	64.7	30.7	5.261	584.999	339.680
HA25	65.8	24.7	3.765	418.651	4.319
HA26	65.8	28.1	3.881	431.549	346.396
HE1	67.1	20.6	3.049	339.035	34.430
HD1	67.6	30.5	2.672	297.114	318.953
HD10	67.6	34.2	3.736	415.426	305.315
HD9	67.6	34.0	3.673	408.421	305.819
HD3	67.7	31.4	2.839	315.684	313.183
HD8	67.7	33.7	3.522	391.63	305.303
HE2	67.7	21.0	2.475	275.209	39.783
HD6	68.1	33.2	3.143	349.487	300.827

**Table 51: Old Helsinki mine locations**

Label	Latitude	Longitude	Distance 1	Distance 2	Azimuth
HD5	68.8	33.0	2.779	309.012	288.881
HD12	69.2	34.7	3.273	363.943	280.184
HD7	69.2	33.3	2.781	309.234	280.580
HD11	69.3	34.4	3.151	350.377	278.445
HD2	69.4	30.8	1.872	208.158	276.626
HD4	69.6	32.3	2.386	265.312	271.612
HF1	69.6	29.9	1.544	171.686	269.630

a. This mine does not have a corresponding new location.

**Table 52: Norwegian mine locations**

Label	Latitude	Longitude	Distance 1	Distance 2	Azimuth
N15	58.300	6.400	13.96	1669.200	28.49
N205	58.800	15.100	11.67	1394.550	18.31
N206	59.300	15.400	11.14	1331.810	18.63
N209	59.700	14.100	10.99	1313.850	21.40
N16	59.750	10.770	11.63	1390.170	26.35
N14	59.900	10.500	11.56	1381.420	27.04
N208	60.000	14.800	10.58	1265.070	20.84
N109	60.100	22.880	9.54	1140.350	5.58
N207	60.100	15.000	10.45	1249.600	20.70
N202	60.120	17.520	10.03	1199.380	16.29
N121	60.140	22.590	9.51	1137.360	6.21
N110	60.170	23.840	9.43	1127.390	3.58
N204	60.185	16.115	10.18	1217.390	18.94
N203	60.200	16.130	10.17	1215.390	18.94
N111	60.250	25.390	9.32	1114.700	0.25
N112	60.270	24.070	9.32	1114.610	3.12

**Table 52: Norwegian mine locations**

Label	Latitude	Longitude	Distance 1	Distance 2	Azimuth
N113	60.300	22.290	9.37	1120.340	6.96
N201	60.620	15.100	9.95	1189.280	21.57
N210	60.700	15.900	9.73	1163.470	20.31
N13	60.740	11.020	10.69	1277.820	28.31
N114	61.030	28.180	8.61	1029.680	353.71
N115	61.050	22.640	8.60	1028.560	6.75
N103	61.180	28.040	8.46	1010.910	353.93
N101	61.330	23.030	8.30	992.660	6.04
N116	61.810	21.740	7.91	945.651	9.66
N6	61.930	5.450	11.18	1335.950	38.48
N117	61.940	29.030	7.76	928.021	350.79
N1	62.040	5.523	11.07	1323.060	38.76
N102	62.040	28.770	7.65	913.888	351.34
N118	62.070	27.410	7.54	901.123	354.89
N122	62.820	29.250	6.91	826.196	349.00
N123	63.020	29.230	6.71	802.434	348.73
N124	63.120	27.740	6.51	777.713	353.05
N119	63.150	24.020	6.44	770.017	4.66
N125	63.160	27.990	6.48	774.690	352.24
N104	63.660	26.050	5.91	705.992	358.14
N105	63.850	25.050	5.71	683.054	1.61
N218	63.867	20.217	6.07	725.049	17.87
N215	63.917	20.100	6.03	721.264	18.37
N219	63.917	20.300	6.01	717.987	17.76
N217	63.933	20.067	6.02	719.931	18.53
N220	64.050	20.717	5.82	696.179	16.82
N9	64.070	11.200	7.85	938.973	39.49
N216	64.100	19.583	5.94	709.582	20.54

**Table 52: Norwegian mine locations**

Label	Latitude	Longitude	Distance 1	Distance 2	Azimuth
N126	64.120	28.060	5.53	661.291	350.64
N214	64.133	18.567	6.07	725.969	23.68
N106	64.410	25.150	5.15	615.717	1.39
N7	64.870	13.880	6.50	776.824	38.77
N157	65.780	24.700	3.79	452.502	4.30
N120	65.900	24.470	3.67	439.132	5.69
N8	65.930	13.880	5.71	682.252	45.46
N213	66.133	17.183	4.65	555.392	38.94
N3	66.421	14.679	5.13	613.573	47.60
N212	67.083	20.967	2.98	356.759	32.32
N5	67.148	16.070	4.24	506.675	51.27
N108	67.790	24.430	1.80	214.831	12.16
N211	67.833	20.205	2.58	308.817	46.13
N400	69.420	30.800	1.87	223.541	276.01
N4	69.652	30.025	1.59	189.976	267.88

**Table 53: Mine locations from other sources**

Label	Latitude	Longitude	Distance 1	Distance 2	Azimuth
TIT	58.23	6.43	14.018	1558.74	28.330
BLA	59.31	6.95	12.940	1438.87	29.989
NYG	60.39	5.34	12.453	1384.72	34.213
Varanger	70.480	28.500	1.40	155.764	228.72

Table 54: JOG mine locations

Label	Latitude	Longitude	Distance 1	Distance 2	Azimuth
JOG1	59.650	9.680	11.97	1430.810	27.55
JOG2	59.660	9.650	11.97	1430.590	27.61
JOG3	59.660	9.690	11.96	1429.460	27.56
JOG4	59.670	9.680	11.95	1428.680	27.59
JOG5	59.680	9.680	11.94	1427.620	27.61
JOG6	59.690	9.540	11.97	1430.510	27.81
JOG7	59.760	9.810	11.84	1415.470	27.63
JOG8	59.770	9.520	11.90	1422.590	28.02
JOG9	59.790	9.500	11.89	1421.050	28.09
JOG10	62.040	10.820	9.61	1148.870	32.28
JOG11	62.100	10.210	9.72	1161.430	33.35
JOG12	62.100	9.800	9.82	1174.200	33.92
JOG13	62.110	9.820	9.81	1172.580	33.93
JOG14	62.110	9.900	9.79	1170.070	33.82
JOG15	62.130	10.090	9.72	1162.150	33.62
JOG16	62.150	10.080	9.71	1160.460	33.70
JOG17	62.150	10.680	9.55	1141.990	32.84
JOG18	62.280	10.320	9.54	1140.030	33.78
JOG19	62.320	10.600	9.43	1127.360	33.51
JOG20	62.330	10.620	9.42	1125.750	33.52
JOG21	62.380	10.400	9.43	1127.580	34.01
JOG22	62.380	10.420	9.43	1126.950	33.98
JOG23	62.410	10.270	9.44	1128.660	34.29
JOG24	62.410	10.280	9.44	1128.350	34.28
JOG25	62.440	10.860	9.26	1107.360	33.53
JOG26	62.440	10.870	9.26	1107.05	33.52
JOG27	62.520	11.220	9.10	1088.34	33.26
JOG28	62.540	11.100	9.12	1090.00	33.51

Table 54: JOG mine locations

Label	Latitude	Longitude	Distance 1	Distance 2	Azimuth
JOG29	62.540	11.250	9.08	1085.42	33.29
JOG30	62.550	11.810	8.93	1067.57	32.44
JOG31	62.570	11.820	8.91	1065.25	32.49
JOG32	62.630	11.550	8.93	1067.29	33.13
JOG33	62.670	11.280	8.96	1071.49	33.69
JOG34	62.690	11.280	8.95	1069.50	33.76
JOG35	62.710	11.280	8.93	1067.50	33.83
JOG36	62.770	11.280	8.88	1061.53	34.05
JOG37	62.790	11.250	8.87	1060.47	34.17
JOG38	62.810	11.260	8.85	1058.17	34.22
JOG39	62.820	10.050	9.16	1095.44	36.05
JOG40	62.840	11.550	8.75	1046.28	33.88
JOG41	62.870	11.630	8.71	1040.84	33.86
JOG42	62.920	11.680	8.65	1034.34	33.96
JOG43	62.940	11.500	8.68	1037.88	34.32
JOG52	67.070	20.970	3.00	358.027	32.16
JOG44	67.180	20.620	2.98	356.104	35.20
JOG45	67.180	20.670	2.97	354.764	34.94
JOG46	67.200	20.670	2.95	352.798	35.16
JOG47	67.200	20.710	2.94	351.728	34.95
JOG68	67.350	32.530	3.40	406.023	313.45
JOG70	67.450	32.660	3.37	402.314	311.74
JOG69	67.550	30.330	2.67	319.011	320.56
JOG53	67.630	21.030	2.52	301.490	38.59
JOG54	67.670	33.630	3.52	420.468	305.89
JOG48	67.830	20.190	2.59	309.557	46.15
JOG49	67.880	20.230	2.54	304.106	46.77
JOG56	67.880	34.550	3.69	441.550	300.89

**Table 54: JOG mine locations**

Label	Latitude	Longitude	Distance 1	Distance 2	Azimuth
JOG57	67.900	34.630	3.71	443.438	300.45
JOG55	67.930	34.480	3.65	435.766	300.36
JOG61	68.010	34.710	3.68	440.043	298.81
JOG60	68.020	34.370	3.56	426.083	299.34
JOG50	68.050	16.020	3.76	448.921	62.25
JOG58	68.150	33.250	3.13	374.669	299.91
JOG59	68.250	33.270	3.09	369.611	298.25
JOG51	68.470	16.050	3.57	426.531	68.19
JOG62	68.690	33.110	2.85	34' 183	290.82
JOG63	68.820	35.370	3.60	429.796	286.09
JOG64	68.870	33.020	2.76	330.386	287.47
JOG65	68.930	33.080	2.77	330.784	286.20
JOG67	69.390	30.330	1.71	204.203	277.14
JOG66	69.420	30.280	1.69	201.685	276.16

